Assessment of Aquifer Mixing and Salinity Intrusion in the North-Western Sahara Aquifer System: a Hydrogeochemical Analysis- Algeria, Tunisia

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Abstract

The North-Western Sahara Aquifer System is a complex multilayer leaky aquifer system providing water to Algeria, Tunisia, and Libya. Changing the hydrologic equilibrium through pumping can cause previously isolated saline water to mix with the fresh water in the pumped aquifers, resulting in increased salinity over time and, creating the potential for water-related conflict. The objective of this study is to identify areas where salinity intrusion is occurring now and could worsen in the future. To accomplish this, fourteen existing datasets were analyzed, yielding new insights into regional and local occurrences of salinity intrusion. Major ion chemistry and ratios of Br/Cl indicate that the source of salinity in the saline aquifers of the system, which intrude into the freshwater, is the dissolution of evaporates in the aquifer matrix. A complex geochemical system where due to the common ion effect gypsum dissolution sustains calcite saturation producing a water rich in Ca and SO_4. Stable isotopes of oxygen and total dissolved solids were the best geochemical indicators of areas of salinity intrusion. Contour mapping of the Total Dissolved Solids and $\delta^{18}O$ has shown that considerable aquifer mixing and salinity intrusion affect the aquifer system. At this time, five areas in the North-Western Sahara Aquifer system are subject to salinity intrusion.

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Introduction

The management of internationally shared water resources depends upon collecting and processing physical and geochemical data to identify changes in an aquifer system over space and time. These studies are specifically important in arid regions of the world with intensive groundwater exploitation. High abstraction rates can diminish water quality and put a strain on non-renewable groundwater reserves. Groundwater resources described as “non-renewable” are defined as, “groundwater resource available for extraction, of necessity over a finite period, from the reserves of an aquifer which has a very low current rate of average annual renewal but a large storage capacity” (UNESCO, 2006). To facilitate efficient management of non-renewable groundwater resources, managers need comprehensive spatial and temporal information on water quality. Providing researchers with a comprehensive database of information in one location provides a reference that allows for easy comparison and tracking of geochemical and physical changes. Access to detailed knowledge about water quantity and quality changes over time in an aquifer system is valuable for determining the future implications for sustainable watershed management to avoid water-related conflicts.

Besides depletion in water quantity, long-term pumping from an aquifer system can change the hydrologic equilibrium, resulting in altered flow regimes. This change in equilibrium can cause previously isolated saline water to mix with the fresh water in the pumped aquifers, resulting in increased salinity over time. In most areas, including the North-Western Sahara Aquifer System (NWSAS), the focus of this study, freshwater both overlies saline water, and transitions to saline water down the pre-development hydraulic gradient. Further, it is possible for low permeability lenses within the fresh water portion of the aquifer to contain saline water; conversely, the lenses could contain freshwater within a saline aquifer. Increases in salinity, over time, can occur when water is withdrawn from the aquifer. Induced hydraulic gradients can cause saline water to move into the freshwater realm. This effect can be directly related to the pumping of a well, in which case the process is called upconing, or generally related to the change in the hydraulic potential field, in which case the process is termed cross-formational flow. These processes are described in more detail below.

Upconing and cross-formational flow are two mechanisms of salinity intrusion that can occur during pumping. Imperfect confining beds can allow saltwater to be pulled into a well during pumping, when the saltwater/freshwater interface moves toward the well in a stable cone shape. If the critical pumping rate is exceeded, the cone will reach the well, causing the production of saline water (Fig. 1a). Saltwater upconing can take several years before deterioration of pumped water occurs and remediation can be difficult (Buddemeier et al., 1995). The degree to which upconing will affect a well depends upon the aquifer and water properties. For example, if the saltwater and freshwater aquifers are not separated by an aquitard, have identical hydraulic conductivities, and the saltwater is 2.5% denser than the freshwater, one foot (30.5 cm) of drawdown of the freshwater head in an aquifer can lead to a theoretical upconing of 40 ft (12 m) of the saltwater/freshwater interface (Rubin et al., 2001). Conversely, if the hydraulic conductivity of the freshwater part of the aquifer is orders of magnitude larger than the saltwater part, the interface may produce a stable cone, that will not reach the well (Rubin et al., 2001). Intruded saltwater will persist within the freshwater portion of an aquifer even after pumping has ceased, and is subject to advection and dispersion, thus having a regional effect.

Cross-formational flow describes the natural or induced movement of water from one aquifer to another. In a multilayer, leaky aquifer system, regional pumping can alter the natural vertical flow direction. For example, in a three-aquifer system with a pre-development upward flow direction, pumping from the intermediate aquifer can lower the head locally or regionally, depending on the extent of pumping, and the lowered potentiometric surface may induce flow from above and/or below into the pumped aquifer (Fig. 1b). This cross-formational flow is called salinity intrusion if the overlying or underlying aquifer is more saline than the intermediate aquifer.

The NWSAS is a large transboundary aquifer system that provides water to Algeria, Tunisia, and Libya. In this desert region the NWSAS is one of the main water resources. The NWSAS is the focus of this study due to the potential for conflict over water rights. There is the potential for cross-formational flow induced by regional pumping to reduce the water quality across a national boundary. The NWSAS is an aquifer system comprising the Plio-Quaternary (PQ), the Complex Terminal (CT), and the Continental

Intercalaire (CI) aquifers, and is located in northern Africa (Fig. 2). The NWSAS covers over 1 million km^2 and is shared by Algeria, Tunisia, and Libya (SASS, 2002). In the year 2000, 2.5 billion m^3 of water was extracted from the NWSAS, as follows: Algeria, 1.5 billion m^3; Tunisia, 0.55 billion m^3; Libya, 0.45 billion m^3 (OSS, 2003). The OSS (2003) predicted that if the year 2000's pumping rates are continued until 2050, the CI water table will drop 40 meters in the Algerian Sahara and 20-40 meters in Tunisia (OSS, 2003). Similarly, the CT is predicted to drop 30 m in Algeria and Tunisia (OSS, 2003). With a continuation of the year 2000 pumping rates and an average yearly population growth in Algeria, Tunisia, and Libya of 2.55% (CIA, 2013), it is likely that water quantity will become a major issue in the near future. The water quantity issue will be exacerbated by a water quality issue induced by pumping. The NWSAS has been the focus of many small scale studies producing a large amount of geochemical and isotopic data in the last twenty years (Abid et al., 2012; Abid et al., 2010; Edmunds et al., 2003; Guendouz et al., 2003; Kamel, 2012, 2013; Kamel et al., 2005; Kamel et al., 2006; Kamel et al., 2008; Moulla et al., 2012; Tarki et al., 2011; Tarki et al., 2012; Yangui et al., 2012; Zammouri et al., 2007).

The objective of the present study is to integrate hydrochemical and isotopic data from fourteen different studies, varying temporally and spatially, to delineate areas where salinity intrusion may be occurring and could occur in the NWSAS. The individual data sets collected between 1994 and 2011 are grouped into one database. The more recent studies of portions of the NWSAS have considered the effects of salinity intrusion in localized areas. Combining data from all of the studies will provide a regional perspective on the evolution of salinity intrusion in the NWSAS and its effects on water quality. The wide range of sampling dates and locations presented in this study provide new insights into the evolution of a complex aquifer system. This collation of data will provide a current database for scientists and managers to conduct further research.

1. Background

The study area extends from the Saharan Atlas Mountain Range and the Tunisian Chotts region in the north to the Tadmaït and Tinerhert Plateaus in the south. In the West, it is limited by the western edge of the Erg Occidental Desert near the border between Algeria and Morocco and in the east it is limited by the Dahar uplands and the eastern border of Tunisia (Fig. 2). The entirety of this area is arid to hyper-arid, with a mean annual precipitation less than 100 mm. The mean annual temperature of 21°C, results in potential evaporation that is greater than 1700 mm/year (Kamel, 2007).

1.1 Geology and Hydrogeology

Within the study area there is considerable variation in lithology and thickness of the aquifers. Several tectonic events have shaped the study area and influenced the hydrodynamics. Uplifts, subsiding basins, and faults characterize the physiography (Fig. 3). For the purposes of this study three regional divisions are contrasted: the Occidental Erg Desert Basin, the Oriental Erg Desert Basin, and the Tunisian Chotts Region. Further, the Chotts Region is sub-divided into the Djerid and Nefzawa regions, reaching to the Dahar uplands (Fig. 2). The Occidental and Oriental Erg Desert Basins are separated by the M'zab uplift, and the eastern portion of the Oriental Erg Desert Basin borders the Tunisian Chotts Region. The CI aquifer is present and hydraulically consistent in each division, the CT is limited to the Oriental Erg Desert Basin and Tunisian Chotts region, and the PQ is limited to the Tunisian Chotts Region. The geologic formations that host the aquifers vary across the study area (Table 1).

1.1.1 The Occidental Erg Desert Basin

In the Occidental Erg Desert Basin the NWSAS is exclusively utilized by Algeria, and has not been studied as extensively as in the Oriental Erg Desert Basin. Geographically, the CI aquifer is split between the two desert basins by the M'zab uplift (Fig. 3). West of the uplift, the CI aquifer in the Occidental Erg Desert Basin is found in the Albian, Aptian, Barremian, and Neocomian of the Lower Cretaceous, and is primarily utilized from Albian clayey sandstone (Table 1). The main recharge areas of the CI are the Saharan Atlas Mountains to the north and the M'zab uplift to the east; minor amounts of recharge occur in the Tadmaït Plateau to the south (Fig. 2). In the Occidental Erg Desert Basin, groundwater in the CI generally flows north to south and the aquifer becomes deeper and thinner in the same direction (Fig. 2). Secondary flow paths may exist extending to the western edge of the desert basin (Moulla et al., 2012) (Fig. 2). The aquifer is generally unconfined in the north and west and confined in the southern portion of the study area. (Moulla et al., 2012). The Cenomanian through Eocence rock formations, which host a portion of the CT aquifer in the NWSAS, crop out in eastern slopes of the M'zab uplift (Fig. 3) (Table 1). In the Occidental Erg Desert Basin, the CT aquifer is locally known as the Erg aquifer and is hosted in the Mio-Plio-Quaternary formations (Moulla et al., 2012). Henceforth, the Erg aquifer will be referred to as the CT aquifer.

1.1.2 The Oriental Erg Desert Basin

The Oriental Erg Desert Basin is characterized by a syncline striking W-E, with an extended southern limb reaching the Tinrhert Plateau (Fig. 4a). In the basin, the CI is found in the Neocomian, Barremian, Aptian, and Albian stages of the Lower Cretaceous (Table 1). It is important to note the presence of a highly saline aquifer beneath the CI in the Upper Jurassic units (Guendouz et al., 2003). In addition, the Cenomanian evaporitic clays confine the CI across the Oriental Erg Basin (Fig. 3). The CI is recharged in the Saharan Atlas Mountains in the north and the Tinrhert Plateau in the south. The primary flow path is from west to east, from Algeria to Tunisia. A secondary flow path, originating in the Tinrhert Plateau, moves from south to north. These flow paths converge at the natural discharge area of the Tunisian Chotts. Several studies have concluded, using various groundwater dating techniques, that the CI aquifer receives little to no modern recharge and is considered a non-renewable resource (Edmunds et al., 2003; Gonfiantini et al., 1974; Guendouz, 1985; Guendouz et al., 1997).

The CT in this region is contained within the Mio-Pliocene deposits that cover nearly the entire basin, the Lower Eocene units in the northern half of the basin, and the Senonian units in the southern half of the basin (Fig. 4a). The Mio-Pliocene deposits are predominately sands that are separated from Late Eocene and Senonian carbonates by a heterogeneous, semi-permeable to impermeable Upper Eocene clay (Guendouz et al., 2003). A minor saline aquifer below the CT aquifer is contained in the Turonian dolomite and is separated from the CT by Lower Senonian clays and evaporites (OSS, 2003). Similar to the CI aquifer, the CT aquifer receives little to no modern day recharge, and is considered a non-renewable resource (Guendouz et al., 2003). Modern recharge of the CT aquifer potentially occurs in the Saharan Atlas Mountains, the eastern slopes of M'zab uplift, the northern slopes of the Tinrhert

Plateau, and direct infiltration from the sand dunes of the Oriental Erg Desert Basin (ERESS, 1972; Guendouz, 1985; Guendouz et al., 2003) (Fig. 2). Groundwater in the CT generally flows from south to north across the Occidental Erg Desert Basin, and discharge occurs at Chott Melrhir and Merouane (Fig. 4a). Additional flow paths could exist from the Dahar uplands to the discharge zone at Chott Gharsa and Chott Djerid.

1.1.3 The Tunisian Chotts Region and Dahar Uplands

The Tunisian Chotts region includes Chott Djerid, Chott Gharsa, and the Tozeur uplift. In northern Africa a “chott” is defined as a continental salt flat in a hydrologically closed basin (Gautier, 1953). Chott Gharsa and Djerid cover an area of nearly 6,000 km^2, and were formed by the interaction of the African and European lithospheric plates during the Late Miocene-Early Pleistocene (Swzey, 2003). Large portions of the Chott surface are covered by an evaporite crust and silty sediments. A series of E-W striking normal faults form the Tozeur uplift between the Chott Gharsa and Djerid, also separating the Djerid and Nefzawa regions (Fig. 4b). The Tozeur uplift acts to compartmentalize the CI and CT and complicates hydrodynamics. The Tunisian Chotts are considered to function as the discharge area of the CI and CT aquifers.

Near the Tunisian Chotts the CI occupies different stratigraphic units due to tectonic activity; a brief summary of the hydrostratigraphy is provided here. In the Djerid region, north of Chott Djerid, the CI is primarily developed in the Sidi Aïch formation at a depth between 1,300 and 2,200 m (Mamou, 1990). In the Nefzawa region, east of Chott Djerid, the CI is primarily developed in the sandstones of the Kébeur el Hadj series at an approximate depth of 1500 m with hydrostatic pressure significantly higher than the ground surface (Edmunds et al., 2003). Where the CI is confined, it is overlain by the Cenomanian Lower Zebbag formation. The CI aquifer nears the surface in the Dahar uplands and receives minor amounts of modern day recharge through infiltration (Fig. 4b, Fig. 4a).

The CT aquifer is contained within the Senonian Abiod limestone formation and the Miocene Beglia sandy clay formation (Kamel et al., 2005). In the Djerid region the CT ranges in thickness from 80 to 120 m and is between 80 and 700 m deep (Mamou, 1990). In the Nefzawa region, the CT ranges in thickness from 30 to 200 m, with a depth between 70 and 250 m (Rouatbi, 1977). The CT crops out in the western slopes of the Dahar uplands, leaving the CI unconfined in a small portion of the Dahar uplands (Fig. 4b). North of Chott Gharsa, the CT is considered to be semi-confined, and generally flows north to south. In the 1980s the CT aquifer acted as two isolated hydrogeologic compartments that flowed away from the Tozeur uplift both to the north and south (Mamou, 1990). By 2006 the potentiometric surface of the CT near the Tozuer uplift had declined nearly 40 m. Groundwater pumping in the area and dry climatic conditions over the past two decades caused the divergent flow regime to be replaced by a south to north flow underneath the Tozeur uplift (Tarki et al., 2011)(Fig. 2). In the Tunisian Chotts Region, extraction from the CT aquifer provides 80% of the agricultural and domestic water supply (Kamel, 2013). Decreases in quality and the rise in illegal abstraction have already been identified as problems for future water management in this area (Zammouri et al., 2007).

The PQ aquifer has only been sampled north of Chott Djerid, in the Tunisian Chotts region, but is still present in the Nefzawa region. The PQ is found in the upper Segui formation, which consists of evaporite- and clay-rich sands creating a complex interconnected system of water bearing layers(Mamou, 1990; Yangui et al., 2012)(Fig. 4b). In most of the Tunisian Chotts region, the PQ aquifer is 100 to 300 m thick and is separated from the CT by the clays of the Segui formation. North of the Chott Gharsa towards the east, the aquitard separating the CT and PQ thins out, causing the CT to become semi-confined (Yangui et al., 2012). The groundwater generally flows away from the Tozeur ridge to Chott Djerid and Gharsa, constituting the discharge area. The PQ aquifer is limited in extent but has important implications for the water quality of the CT aquifer, due to limited hydraulic connection varying over the Tunisian Chotts region (Kamel, 2013; Yangui et al., 2012).

2. Methods

The geochemical data were collated from fourteen studies of the NWSAS, and includes 659 geochemical and isotopic analyses collected between 1994 and 2011. The references from which these data were originally reported are numbered 1 through 14 in order to differentiate data sets. Summaries of each publication can be found in the appendix (Appendix1). The data were organized into a single database, with major ions in mg l^{-1}, mmol l^{-1}, and meq l^{-1}; minor ions in μg l^{-1} and μmol l^{-1}; and other pertinent data (Appendices 2-5). For quick reference a statistical summary of the data is provided (Table 2). The latitude and longitude coordinates of wells were not provided in all studies. For those wells, the latitude and longitude coordinates were estimated from the study area maps that included well names. All wells were formatted in ArcMap and populated into the database. Saturation indices (SI's) were calculated using the PHREEQC-3 geochemical modeling software (Parkhurst and Appelo, 2013). The calculations were performed with the phreeqc.dat database, using the temperature, pH, and m l^{-1} concentrations of Na, K, Ca, Mg, SO_4, Cl, and alkalinity as HCO_3^-. The pe was assumed to be 4, and density of water was assumed to be 1 g cm^{-3}. Samples with high TDS values will have water densities greater than 1 g cm^{-3}. An estimated water density of 1.02 g cm^{-3}, based on the sample with the highest TDS (12700 mg l^{-1}), was used to calculate the saturation indices and resulted in differences within ± .01, within the calculation error.

3. Results and Discussion

The CI, CT, and PQ aquifers have average total dissolved solid (TDS) values of 1870, 2990, and 7240 mg l^{-1}, respectively (Table 2). A value of 1000 mg l^{-1} TDS is considered saline, but usable in water-stressed areas; values above 3000 mg l^{-1} are considered unfit for domestic and agricultural use (Alley, 2003). Many of the CI and CT aquifer water samples are close to or exceeding 3000 mg l^{-1} TDS, with the majority of the water samples from the PQ aquifer above this limit. In this study, water samples with TDS greater than 3000 mg l^{-1} are considered highly saline, in that they are unfit for most irrigation or consumption uses.

The dominant anions in the water samples are chloride and sulfate, and the dominant cations are sodium and calcium. Three water types are present in the aquifer system: Ca-SO_4-Cl, Na-Cl, and mixed (Fig. 5), based on the Davis and De Wiest (1996) classification. The mixed-type waters are characteristic of some of the samples from the Occidental Erg Basin. This may be due to differences in lithology and the absence of the Turonian-Cenomanian aquitard. Gypsum, halite and other minor salts are found in many of the geologic units and are the main contributors to salinity. The major ions in these minerals and their saturation states are used to explore the processes of mineralization.

The data are considered regionally across the study area and locally in the Tunisian Chotts region, to provide insights into sources of salinity and aquifer mixing. The CI and CT aquifers occupy multiple rock stratigraphic units and are generally continuous across the study area, except as already described above. In this discussion, water-rock interaction will be explored to confirm the sources of salinity in the aquifers and determine if there are any discrepancies with flow path mineralization. Next, a discussion of the δ^2H and $\delta^{18}O$ stable isotopes is presented to classify average isotopic signatures of each aquifer and to identify mixing. Lastly, geochemical and isotopic contour maps are used to highlight areas where the $\delta^{18}O$ and total dissolved solids are indicative of mixing and increases in salinity.

3.1 Water-Rock Interaction

4.1.1 Saturation indices and Major Ions

The calculated saturation indices provided in the original studies are nearly identical to the calculations performed in this study. Saturation conditions are expressed as undersaturated (SI<0.5), supersaturated (SI>0.5), and saturated (0 ± 0.5). Researchers have suggested various mechanisms for the observed dominant ion concentrations and saturation indices with respect to calcite, gypsum, and halite. Some of these studies hypothesize that gypsum and halite dissolution, with calcite precipitation are the main controls on dominant ion concentrations. Additional hypotheses of secondary processes include incongruent dissolution of dolomite , Ca-Na cation exchange, epsomite dissolution , pyrite oxidation , and CO_2 outgassing (Abid et al., 2012; Abid et al., 2010; Edmunds et al., 2003; Guendouz et al., 2003; Kamel, 2013; Kamel et al., 2005; Kamel et al., 2006; Kamel et al., 2008; Tarki et al., 2011; Tarki et al., 2012; Yangui et al., 2012). In this study it is proposed that two major groups of ions, Ca-HCO_3-SO_4 and Na-Cl, form two related but distinct geochemical systems in the groundwater, which influence major ion concentrations and saturation indices. These geochemical systems are discussed further below.

This study proposes that the Ca-SO_4-HCO_3 system is mainly influenced by the common ion effect in the direction of groundwater flow. The groundwater is saturated to supersaturated with respect to calcite throughout the entire general flow path (Fig. 6a). Conversely, the gypsum SI's asymptotically approach saturation from undersaturation with increasing Ca and SO_4 concentrations. The increase in gypsum SI represents a transition from recharge to discharge areas (Fig. 6c). Along the flow path and at the discharge areas, gypsum is dissolved, increasing the Ca and SO_4 concentrations. Increased Ca concentrations cause calcite precipitation due to the common ion effect, while calcite saturation is maintained. Additionally, the calcite precipitation results in undersaturation with respect to gypsum, allowing more gypsum to dissolve until gypsum saturation conditions are reached near the discharge area. A comparison of the Ca/HCO_3 equivalents ratio vs. HCO_3, indicates a surplus of Ca relative to HCO_3 (Fig. 6b). The end result of the system is a groundwater with high SO_4 and relatively low Ca concentrations, shown in the Ca/SO_4 ratio vs. SO_4 graph (Fig. 6d).

Halite SI's suggest that the Na-Cl system is governed by halite dissolution, and that the waters are highly undersaturated with respect to halite. The increase represents the transition from wells in the recharge areas to discharge areas (Fig. 6e). Considering Na/Cl equivalents ratio vs. Cl concentrations, an imbalance of Na and Cl is indicated (Fig. 6f). Congruent halite dissolution with no other chemical reactions would produce a unit ratio for all the Cl concentrations. The samples that have Na/Cl ratios above 2, may represent where Na has been released from silicate weathering. The reaction of feldspar minerals with carbonate acid in groundwater can release Na into the groundwater causing high Na/Cl ratios. Additionally, in a higher salinity water, the dominate exchangeable cation is Na. Conversely, in a more fresh water Ca is the dominant exchangeable cation (Drever, 1997). Reverse cation exchange reactions with clay minerals will release Ca and bind Na, lowering the Na/Cl ratios in the groundwater. These two processes are controlling the Na/Cl ratios based on the mineralogy of the aquifer.

4.1.2 Br/Cl and SO_4/Cl

Br/Cl weight ratios with simple conservative mixing relationships can differentiate sources of chloride in an aquifer (Whittemore, 1995). Br/Cl weight ratios in a natural halite dissolution brine can range from 0.00006 to 0.0005; Br/Cl weight ratios from 0.0005 to 0.04, are indicative of oil field brines, and weight ratios from 0.0003 to 0.1 are indicative of freshwater (Whittemore, 1995). With the overlap in the ratios it is important to take into account the total chloride in the water. A bi-variate diagram of Br/Cl weight ratio vs. Cl (mg l^{-1}) can illustrate simple conservative mixing relationships. Three possible end members were established to represent a freshwater sample from the recharge zone of the NWSAS, a hypothetical high chloride solution of pure dissolved halite, and hypothetical oil and gas brine. Mixing curves generated from the end member points constrain a zone of freshwater mixing with the hypothetical halite solution, and a zone of freshwater mixing with the oil and gas brine (Fig. 7A). Samples falling in the halite-dissolution-freshwater mixing zone represent halite dissolution in the aquifer as the source of salinity. The two samples falling in the oil and gas brine-freshwater mixing zone (group 3) indicate mixing with an oil and gas brine in the aquifer. Additionally, Group 1 (Fig. 7A), represents the CI groundwater flow path in the Occidental Erg Desert basin, and group 2 represents the CI, CT, and PQ groundwater in the Oriental Erg Desert basin and Tunisian Chotts region (Fig. 7A). As the Cl content increases along the flow path indicated by the arrow in group 1, the Br/Cl ratio decreases, supporting the hypothesis that halite dissolution is the source of Cl in the Occidental Erg desert basin. Within group 1, the highest Br/Cl ratios (0.05-0.06) are located in the Saharan Atlas Mountains recharge area (Fig. 7A). The CT and CI aquifers in the Oriental Erg desert basin (group 2) do not show distinct trends with increasing chloride. The Br/Cl ratios for the CI and CT aquifers could be affected by increased Br from infiltration affected by evaporites in the recharge area and small increases in Br from marine-derived formation waters along the flow paths (Edmunds et al., 2003; Guendouz et al., 2003). Overall, the low Br/Cl ratios indicate dissolution of halite from the rock stratigraphic units containing evaporites as the primary source of chloride in the NWSAS.

Similar to Br/Cl, SO_4/Cl ratios can help differentiate sources of sulfate in an aquifer (Whittemore, 1995). Weight ratios less than 0.05 are attributed to evaporative concentration and mixing with oil and gas brine, values between 0.03 and 0.4 are attributed to natural evaporate dissolution brine, and values between 0.05 to 50 represent freshwater (Whittemore, 1995). The SO_4/Cl ratios in the NWSAS range from freshwater to water affected by natural evaporite dissolution, most likely gypsum or anhydrite (Fig.

7B). A majority of the SO_4/Cl ratios are greater than unity, because of more plentiful soluble mineral sources of sulfate than chloride, such as epsomite, thenardite, and mirabilite (Kamel, 2013). Increased dissolution of halides will also increase the solubility of gypsum or anhydrite due to ionic strength effects (Bock, 1961).

3.2 Water Stable Isotopes

The stable isotopes of hydrogen and oxygen can provide information about aquifer recharge and mixing. The aquifers of the NWSAS exhibit distinct stable isotopic signatures: the average δ^2H and $\delta^{18}O$ compositions of each aquifer are CI, -56‰, -7.0‰; CT, -50‰, -5.9‰; and PQ, -45‰, -4.9‰ (VSMOW) (Table 2). The range for each aquifer is CI, -73‰ to -35‰ and -9.2‰ to -2.2‰; CT, -72‰ to -25‰ and -9.2‰ to -3.9‰; and PQ, -52‰ to -29‰ and -7.3‰ to -2.2‰. The isotopic values of certain wells deviate significantly from the average isotopic composition, indicating a variety of processes including aquifer mixing, different sources of recharge, and well processes. These processes will be discussed in detail below.

The water stable isotope data were separated into two sets. The first set comprises the area with a high density of data in Tunisian Chotts Region (inset map, Fig. 2), and the second set, here called regional-flow data, comprises the data in the rest of the study area, including the regional recharge areas and flow paths. An extensive amount of data has been collected in the Tunisian Chotts Region, due to the aquifers importance for sustaining domestic and agriculture water supplies. The δ^2H and $\delta^{18}O$ values are plotted in relation to Craig's (1961) global meteoric water line (GMWL, $\delta^2H = 8.13\ \delta^{18}O + 10.8$), the local meteoric water line (LMWL, $\delta^2H = 7.15\ \delta^{18}O + 7.92$), and the modern annual mean precipitation values for the region, δ^2H- 26‰, $\delta^{18}O$ -5.1‰ (VSMOW) (Edmunds et al., 2003). The data for each aquifer mostly plot below the GMWL and are lighter than the average for modern rainfall (Fig. 8 a,b). Coupled with carbon isotope data, the hydrogen and oxygen isotopes indicate the aquifer recharge occurred at lower temperatures during the Late Pleistocene and Early Holocene (Edmunds et al., 2003; Guendouz et al., 1997). Radiocarbon data from the Saharan Atlas Mountain range have activities between greater than 60 % modern carbon (pmc), 200 to 600 km from the Saharan Atlas Mountain range have activities between 0 and 2 pmc, and finally near the discharge areas the activities reach the effective detection limit of 0.5 pmc, indicating ages of 30,000 years before present (Edmunds et al., 2003). Many researchers suggest that modern recharge is minimal in this region and that the African Humid period, from 14,800 to 5,500 years BP, represents the most recent period of significant recharge to the Sahara desert in northern Africa (Patricola and Cook, 2007).

Another process that might be occurring to explain the isotope deviation from the GMWL is the “amount effect”. The stable isotopic signatures could have been influenced by precipitation amount and intensity (Clark and Fritz, 1997). During a large rain event the isotopic signature of the precipitation changes over time. The $\delta^{18}O$ values can decrease as much as 10‰ after reaching landfall (Good et al., 2014). Large rainfall events during the African Humid period may have contributed large amounts of recharge to the aquifer system from tropical storms.

In the Tunisian Chotts, the isotopic compositions of water samples from each aquifer suggest that considerable mixing has occurred (Fig. 8). The largest geographic features in this area are Chott Gharsa, Chott Djerid, and the Tozeur uplift (Fig. 2). The Chotts-area water-stable isotope plot suggests that the CT aquifer is influenced by water from the CI and PQ aquifers (Fig. 8a). The samples in ellipse 1 are from wells that show upward leakage from the CI with low δ^2H and $\delta^{18}O$ decreasing the δ^2H and $\delta^{18}O$ in the CT in the range of 1 to 5‰ in $\delta^{18}O$ (VSMOW) and 1 to 10‰ in δ^2H (VSMOW). This is possibly due to weak hydraulic connections, which allow water from the CI aquifer with similar chemistry to enter the CT aquifer. Samples in ellipse 2 are from wells completed in the CT and PQ aquifers that have similar isotopic values. Depending on location, this has been attributed to two different processes. First, in the area north of Chott Gharsa, isotope mixing analysis determined that 30-60% of the PQ groundwater is composed of upward leakage from the CT aquifer; the amount of leakages decreases from west to east (Yangui et al., 2012). Second, in the area between Chott Gharsa and Chott Djerid, pumped CT water is used for flood irrigation, undergoes evaporative concentration, dissolution of surface salts, and finally recharges into the shallow PQ aquifer (Kamel, 2013; Kamel et al., 2005; Kamel et al., 2006; Tarki et al., 2012). The varying amounts of evaporation of the PQ water, due to variations in ground cover, create a gradual evaporation line in ellipse 2, which trends away from the CT water isotope mean (Fig. 8a). High extraction rates in the CT aquifer have dropped potentiometric levels allowing PQ water to leak downward, resulting in salinity increases in shallow CT aquifer (Yangui et al., 2012).

Aquifer samples with un-mixed isotopic signatures are possibly due to limited hydraulic connections between the PQ and CT because of local aquitard thickening or lower permeability. A detailed spatial characterization of the thickness of the Zebbag Formations between the CI and CT, and the Segui Formation clays between the CT and PQ is needed to confirm hydraulic connections or lack thereof between the aquifers.

The regional-flow water-stable-isotope plot (Fig. 8b) includes data from the Occidental Erg Desert Basin, the Oriental Erg Desert Basin, and the Dahar Uplands. The isotope data demonstrate a wider range of values than found in the Chotts region (Fig. 8a), with average δ^2H and $\delta^{18}O$ values for the CI of -56‰ and -7.1‰, and ranges of -82‰ to -34‰ and -9.2‰ to -2.1‰; and for the CT of -50‰ and -5.7‰, and ranges of -73‰ to -26‰ and -9.2‰ to -3.9‰. The group of data enclosed in ellipse 3 (Fig. 8b) are from wells located in foothills of the Saharan Atlas Mountains, the Dahar uplands, and the southern plateaus. These wells are in the recharge areas for the CT and CI and the trend of this group of data toward the isotopic ratios of modern precipitation suggests some modern recharge may be occurring. Line 1(Fig. 8b) shows theoretical mixing between average isotope ratios in the CI and CT aquifers in the Oriental and Occidental Erg Desert Basins. In the Oriental Erg Desert Basin, upward leakage and/or upwelling through the Cenomanian Formation has caused a depletion of δ^2H and $\delta^{18}O$ in the CT isotopic signature. The CI samples enriched in ^2H and ^{18}O are from the Occidental Erg Desert basin. Moulla et al. hypothesize that periodic flooding in the western portion of the Occidental Erg Desert Basin contributes evaporated water to the CT aquifer, which finally mixes with the CI in the unconfined western portion (Moulla et al., 2012).

3.3 *Contour Maps*

This study uses the spatial distribution of the $\delta^{18}O$ stable isotope ratios to identify the areas that are receiving modern recharge, as well as areas influenced by cross-formational flow from other aquifers.

Similarly, the spatial distribution of TDS is used to propose areas where cross-formational flow of more saline water reduces water quality. For example, an area of elevated TDS in a fresh-water aquifer could be interpreted as sourced from leakage from a more saline aquifer below or from infiltration of evapo-concentrated water from above. Water stable isotope ratios will be heavier for evapo-concentrated water than for deep saline-aquifer water, and so will better distinguish the correct salinity source. The $\delta^{18}O$ values show areas where aquifer mixing or cross-formational flow could be occurring, while the TDS values determine any changes in salinity associated with the possible mixing. These two pieces of information will allow a greater understanding of the areas at risk for salinity intrusion and water quality decline.

Presented here are maps segregated by region and by aquifer in order to gain insight into the individual changes occurring in each area and aquifer. If salinity intrusion is occurring a pattern showing localized changes in TDS and $\delta^{18}O$ should emerge indicating the direction of intrusion and the amount of change in salinity. The first set of contour maps shows the spatial distribution of $\delta^{18}O$ and TDS in all three aquifers in the high-data-density area of the Tunisian Chotts region (Fig. 9). The second set of maps shows regional distribution of $\delta^{18}O$ and TDS of the CI and CT aquifers (Fig. 10) (Fig. 11).

3.3.1 Tunisian Chotts Region

The water stable isotopes and salinity of the CT aquifer in the Tunisian Chotts Region suggest mixing of groundwater from different sources, as detailed here. Water stable isotopes (Section 4.2) suggest both upward and downward leakage is occurring in the Tunisian Chotts region. In the CT aquifer in the northern part of the Chotts region, isolated occurrences (closed contours) of depleted (-7‰) values suggest upward leakage. (Fig. 9). Although published values of water stable isotopes of the CI groundwater are not available in the northern part of the Chotts Region map, the isotopic ratios are most likely consistent with the rest of the CI aquifer, considering a similar recharge history and flow path from the west. If this assumption holds, then the depleted isotopic values in the CT are likely caused by upward leakage from the CI north of Chott Gharsa. The TDS values in the CT north of the Chott Gharsa are relatively high (Fig. 9), which is not directly supported by upward leakage of the relatively fresh water in the CI. However, upward migration of CI water through the saline Turonian-Cenomanian aquitard could increase the salinity of the CI water leaking into the CT.

In the northern part of the map area, the PQ aquifer is also slightly depleted in ^{18}O ($\delta^{18}O$ of about -5.5‰) compared to the southern part ($\delta^{18}O$ of about -4.5‰), and has TDS greater than 4000 mg l^{-1}. The combination of these characteristics supports the hypothesis of upward leakage of and mixing with CT water. In contrast, the area between Chott Gharsa and Chott Djerid the CT contains isotopically enriched values (about -5‰) with respect to the CT aquifer average (-5.9‰) and TDS values between 2500 and 3500 mg l^{-1} TDS. These data support the idea that downward leakage of evaporated PQ water is degrading the water quality in the CT aquifer. The contour maps confirm that upward and downward leakage are salinizing the CT aquifer north of Chott Gharsa and south of Chott Gharsa, respectively.

The TDS of CI groundwater in the Tunisian Chotts region changes over a very short distance from 1000 to 8000 mg l^{-1}, a very steep gradient, while there is little change in the $\delta^{18}O$ (Fig. 9). If the Jurassic aquifer below the CI, known to contain brine, has a similar $\delta^{18}O$ value to the CI groundwater, an increase in TDS from saltwater upconing, could being occurring without a shift in isotopic $\delta^{18}O$ values. Water stable isotope ratio measurements from the Jurassic aquifer are needed to test this hypothesis.

3.3.2 Regional-flow study area

The $\delta^{18}O$ isotopic values of the CI change little across the regional-flow study area, with a total range of about 3‰ (Fig. 10). Even so, three portions of the regional study area show some patterns suggestive of hydrologic processes that will be addressed next. First, within the far western part of the Occidental Erg Desert Basin the $\delta^{18}O$ values are enriched by about 2‰ relative to the eastern part, along with insignificant increases in TDS. Moulla et al. (2012) suggested that this isotope shift without change in the TDS results from the periodic infiltration of floodwater (Moulla et al., 2012). Second, across the northern portion of the Oriental Erg Desert Basin and through Tunisia the CI groundwater $\delta^{18}O$ is fairly constant at about -8‰. The TDS of the CI in the Oriental Erg Desert Basin increase from west to east, the general direction of regional groundwater flow. In the Tunisian Chotts region the TDS values are at or above 3000 mg l^{-1}, with lower values in the Dahar Uplands. This increase in TDS from west to east, with little change in water isotope ratios suggests dissolution of minerals along the flow path instead of salinity intrusion from above or below. The contour maps indicate that upconing and leakage to the CI aquifer is a minimal contributor to salinity along the flow paths, likely due to relatively consistent confining layers. Third, in the northern portion of the Oriental Erg Desert the 1500 mg l^{-1} contour line bends upgradient. Groundwater pumping upgradient from the bend in the contour line could be locally reversing the groundwater flow direction. The higher TDS groundwater is moving in the reverse direction of the regional flow system to the pumped wells. The regional-flow data suggests that the CI aquifer is generally separated from the CT aquifer until it reaches the western and eastern boundaries of the study area.

The water stable isotopes and TDS in CT groundwater varies in a complicated way across the regional-flow study area (Fig. 11). Three areas will be discussed here. First, in the northeast, the $\delta^{18}O$ values become progressively depleted (from -5‰ to -8‰) toward the Tunisian Chotts region. The CT groundwater TDS also increases approaching the Tunisian Chotts region, especially south east of Chott Djerid. This may be attributed to heavy CT groundwater use in the area, which moves CI groundwater into the CT aquifer. Second, along the western margin of the regional-flow study area, three small areas stand out with elevated TDS concentrations as evidenced by closed contours. Each of these areas also has closed contours of $\delta^{18}O$ values, and the $\delta^{18}O$ data suggest upward leakage from the CI aquifer. However, the TDS of the CI groundwater in this area (Fig. 10) is generally less than that of the CT, so the leakage of the CI groundwater into the CT aquifer should result in lower, not higher, TDS. Therefore, if upward leakage is occurring the CI water is accumulating dissolved salts as it moves into the CT aquifer. Third, the CT groundwater in the Dahar Uplands and near the Gulf of Gabes exhibit a wide range in TDS values (from 1500 to 6000 mg l^{-1}) and depleted isotopic ratios (-7‰) compared to the CT average of -6‰. The changes in salinity can be attributed to a combination of upward leakage through the local fault system, and infiltration of saline evaporated water. In this same area, in the Nefzawa sub-division, south-east of Chott Djerid, the CT aquifer exhibits a significantly variable TDS and $\delta^{18}O$ values. The TDS of the CT groundwater in the Nefzawa Region changes over a very short distance from 2000 to 5000 mg l^{-1}, a very steep gradient, while the $\delta^{18}O$ values range from -4.5 to -6.0‰ (Fig. 11). The Nefzawa region is another area where heavy groundwater use has influenced the groundwater chemistry. A mix of upward and downward leakage, in the northern and southern Nefzawa respectively, can be attributed to lithologically influenced changes in hydrologic equilibrium caused by decreases in the piezometric levels in the CT (Zammouri et al., 2007). In the northern Nefzawa, the larger decreases in piezometric levels cause upconing of saline water from the CI, while in the southern Nefzawa where the CT aquifer is closer to the surface backflow of drainage water is the primary source of salinity in the CT aquifer (Fig. 4) (Zammouri et al., 2007).

4.4 Salinity intrusion map

The many types of groundwater mixing and the processes causing the mixing are summarized by shading areas of the study area that currently show evidence of compromised groundwater chemistry (Fig. 12). These are: upward leakage of the CI and CT into the PQ in the area north of Chott Gharsa (area 1), downward leakage of the highly saline PQ groundwater into the CT in the area between Chott Gharsa and Chott Djerid (area 2), upward leakage from the CI to the CT in the western boundary of the CT aquifer (area 3), a mix of upward and downward leakage to the CT in the Nefzawa region (area 4), and upward leakage in eastern Tunisia (area 5) (Fig. 12). Each of these areas have wells that have produced groundwater with TDS near or above 3000 mg l^{-1}. The water quality is affected by salinity intrusion and the water quality could significantly decline as further pumping changes the hydrologic equilibrium. The two main processes of salinity intrusion in the NWSAS are upward leakage through layers containing saline water and/or soluble evaporites, and the infiltration of evaporated irrigation water down into the PQ and CT aquifers. The upward leakage from the deep CI aquifer takes place in the deeply faulted areas and where the confining layer is inconsistent, providing relatively small areas of focused flow. A primary example of this upward leakage occurs in near the Tozeur uplift in between the Chott Gharsa and Chott Djerid. Conversely, the infiltration of highly saline water into the PQ and CT aquifers is a function of the return flow from the long-term practice of flood irrigation in the Tunisian Chotts region. These two processes are the main contributors to the decline in water quality in the NWSAS.

4. Conclusions

The NWSAS is a vast aquifer system, and a critical water supply for Algeria, Tunisia, and Libya. In this study, previously published geochemical and stable isotopic data from the CI, CT, and PQ aquifers helped determine that evaporites such as halite, gypsum, and calcite are the major sources of salinity, a high degree of aquifer mixing is occurring in the Tunisian Chotts region, and that mixing has negatively affected the water quality of the CT and PQ aquifers. This study illustrates the utility of combining regional isotopic and geochemical data in order to identify areas susceptible to decreases in water quality. Additionally, a complete geochemical dataset is provided for future regional studies of the NWSAS.

Water-rock interaction in the system is highly complex and is governed by dissolution of evaporites. Analysis of the regional geochemical data indicates that a complex geochemical system governs the water chemistry. Utilization of the saturation indices with respect to calcite, gypsum, and halite indicate that the system dissolves halite and gypsum while precipitating calcite due to the common ion effect. This creates a system saturated with respect to gypsum and calcite, high in SO_4, and relatively low in Ca. The Br/Cl and SO_4/Cl ratios corroborate the dissolution of gypsum and halite as the main contributors to salinity. These ratios preclude oil brine as a salinity sources in the NWSAS. The intercalations of evaporites in the aquitards of the system are the likely contributors to the TDS increases along the flow paths and during aquifer mixing. A better understanding of the evaporites within and surrounding the major aquifers would provide greater insight into the sources of salinity.

Following the analysis of sources of aquifer mineralization, the groundwater stable isotope composition provides evidence for aquifer mixing. The averages for each aquifer provide references to determine mixing between the aquifers and with modern rainfall. δ^2H and $\delta^{18}O$ values show mixing between the CI and CT, between the CT and PQ, and minor inputs from modern rainfall.

Contour mapping of the TDS and $\delta^{18}O$ values provides further insight into where the aquifer system is subject to salinity intrusion. The contour maps indicate that minimal upconing and cross-formational flow produce salinity intrusion in the CI. The contour maps of the CT indicate the presence of several areas where upconing and cross-formational flow have impacted the water quality. The Tunisian Chotts region shows the greatest variability in TDS and $\delta^{18}O$ values in the CT in the study area with a mix of upward and downward leakage causing a decrease in the water quality. The CT aquifer is influenced by recharge from the higher salinity PQ aquifer throughout the Tunisian Chotts region. Similarly, an area was identified in the Oriental Erg Desert Basin where regional groundwater abstraction is causing the CT aquifer to flow in the reverse direction moving higher salinity groundwater in the pre-development flow direction. Large gradients in TDS values indicate that localized pumping may be causing small scale upconing, causing saline water to enter individual wells in the CT.

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Tables

Table 1 Generalized stratigraphic and hydro-stratigraphic units of the NWSAS (sdy-sandy, cl-clay, cly-clayey, gyp-gypsum, anhy-anhydrite, hal-halite, ls-limestone, dol-dolomite, mrl-marl, and sst-sandstone) (Adapted from OSS, 2003 and Kamel et al., 2005)

Era	Period	Epoch/Stage	Stratigraphic Units (Rock Description)				Hydro-stratigraphic Units	
			Occidental Erg Desert Basin	Oriental Erg Desert Basin	Tunisian Chotts Region to Dahar Uplands			
					Djerid Division	Nefzawa Division		
Cenozoic	Quaternary	Pleistocene-Holocene	(sdy cl and gyp)	(sdy cl and gyp)	Segui Fm. (sdy cl with gyp)		Plio-Quaternary Aquifer	
	Neogene	Mio-Pliocene	(cl)	(cl)	Segui Fm. (cl)		Aquitard	
			(alternating sd and cl)	(alternating sd and cl)	Beglia Fm. (sdy cl)		Upper	Complex Terminal Aquifer
	Paleogene	Upper Eocene		(cl, anhy, hal)			Leaky Aquitard	
		Lower Eocene		(ls)			Lower	
Mesozoic	Cretaceous	Upper Senonian		(ls, dol)	Abiod Fm. (fis ls)			
		Lower Senonian		(cl, anhy, and hal)	Aleg Fm. and Upper Zebbag Fm. (cl and evap, ls)		Aquitard	
		Turonian		(dol, ls)	El Guettar Fm. (dol, ls)		Minor Saline Aquifer	
		Cenomanian		(cl)	Lower Zebbag Fm. (cly dol)		Aquitard	
		Albian	(cl Sst)	(cl sst)	Orbata Fm. (sst, ls, mrl)		Continental Intercalaire Aquifer	
		Aptian	(alternating dol, anhy, and cl beds)	(alternating dol, anhy, and cl beds)	Sidi Aïch Fm. (sst)			
		Barremien	(sst)	(sst)	Bouhedma Fm. (silt, clay, dol)	Wood series (sst)		
					Boudinar Fm. (cl, sst)			
		Neocomian	(cl and anhy)	(cl and anhy)	Sidi Kralif Fm. (clay, sst)	Kbar el Haj series (sst)		

Table 2 Statistics of geochemical and isotopic data from each dataset and each aquifer

Ref. # / aquifer	Number of Samples	Statistic	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	SO_4 (mg/l)	Cl (mg/l)	HCO_3 (mg/l)	δ^2H	$\delta^{18}O$
1/CI	49	Min.	6.9	964	97	30	73	8	294	159	33	-68	-9.1
		Max.	8.5	12705	889	279	3500	110	1840	5960	256	-40	-6.3
		Average	7.4	2332	254	72	393	40	802	612	145	-60	-8.0
		SD	0.3	1615	118	35	473	21	373	801	37	4	0.6
2/CT	35	Min.	6.5	947	68	24	172	9	321	164	58	-72	-9.2
		Max.	8.0	6948	719	630	1450	50	1990	2500	159	-47	-4.9
		Average	7.4	3085	332	133	551	24	1044	881	107	-57	-6.6
		SD	0.3	1345	143	101	267	8	403	529	27	7	1.1
3/CI	11	Min.	6.9	1766	285	30	182	46	757	286	110	-62	-7.6
		Max.	8.2	4258	412	67	996	114	1730	1680	256	-55	-6.8
		Average	7.2	3041	357	44	483	71	1271	507	155	-58	-7.3
		SD	0.4	752	41	10	217	19	321	382	41	2	0.2
3/CT	31	Min.	5.6	1470	136	35	169	4	350	341	102	-54	-6.2
		Max.	8.1	5880	624	247	1600	32	1685	2449	268	-43	-3.9
		Average	7.4	2979	294	126	419	19	955	748	158	-48	-5.1
		SD	0.6	903	111	47	257	7	326	439	42	3	0.7
3/PQ	15	Min.	6.6	4940	536	106	299	17	1680	750	98	-49	-5.3
		Max.	8.0	7700	880	350	1960	55	3000	2485	366	-29	-2.2
		Average	7.3	6495	728	258	815	33	2414	1397	229	-43	-4.2
		SD	0.4	945	95	68	433	10	307	507	87	5	0.9
4/CI	16	Min.	7.0	1620	134	24	293	13	437	294	73	-68	-8.9
		Max.	8.4	8029	843	353	1181	98	2455	2516	244	9	0.8
		Average	7.6	3563	351	95	689	46	962	1149	120	-58	-7.8
		SD	0.4	1282	158	55	296	26	295	621	29	8	0.7
4/CT	31	Min.	7.2	542	54	24	76	3	108	119	12	-60	-8.3
		Max.	8.4	8029	843	353	1165	90	2455	2057	244	-25	-5.3
		Average	7.7	3029	318	126	427	34	1189	663	125	-47	-6.9
		SD	0.3	1594	168	67	217	27	587	457	62	9	0.8
5/CI	6	Min.	6.9	1800	201	19	182	25	757	286	91	-60	-7.5
		Max.	8.2	3500	470	111	539	89	1701	437	179	-55	-7.3
		Average	7.5	2612	322	46	359	57	1126	357	132	-57	-7.4
		SD	0.5	523	81	32	114	21	298	58	29	2	0.1
5/CT	31	Min.	6.8	1600	164	33	169	4	521	288	70	-52	-7.0
		Max.	7.9	6560	521	203	1076	65	1805	1834	347	-40	-4.1
		Average	7.3	3078	328	105	437	21	1067	694	146	-45	-5.2
		SD	0.2	1146	92	43	209	11	311	319	49	3	0.8
5/PQ	6	Min.	7.2	4600	470	119	694	11	1609	852	73	-52	-7.3

Ref. # / aquifer	Number of Samples	Statistic	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	SO_4 (mg/l)	Cl (mg/l)	HCO_3 (mg/l)	δ^2H	$\delta^{18}O$
		Max.	8.1	5180	817	268	848	60	2880	1344	225	-41	-6.2
		Average	7.3	3641	386	123	623	36	1197	1013	133	-48	-6.8
		SD	0.3	220	111	52	51	17	457	158	47	4	0.4
6/CT	38	Min.	6.4	1162	100	73	131	20	355	277	128	-54	-7.4
		Max.	6.9	5567	960	326	1133	113	1878	2953	201	-42	-3.9
		Average	6.7	3505	425	158	474	48	1087	1080	153	-48	-5.2
		SD	0.1	1007	184	61	166	18	349	620	17	3	0.9
7/CI	39	Min.	6.7	37	101	22	138	8	336	188	51	-73	-9.2
		Max.	8.2	2970	1007	641	1465	168	4099	3487	232	-36	-6.2
		Average	7.5	1155	362	92	501	49	1006	883	125	-57	-7.8
		SD	0.4	872	197	103	325	32	603	712	43	9	0.8
7/CT	13	Min.	6.7	13	99	44	235	19	171	204	6	-63	-8.3
		Max.	8.1	298	507	111	748	1444	1789	1455	226	-39	-6.7
		Average	7.6	141	321	79	458	388	978	712	115	-55	-7.5
		SD	.4	110	125	22	165	610	400	328	60	8	0.7
8/CI	22	Min.	7.1	1827	185	30	281	38	645	320	110	-	-
		Max.	8.2	3650	445	88	726	90	1710	1360	256	-	-
		Average	7.4	2652	312	61	428	49	1030	609	140	-	-
		SD	0.3	508	66	17	122	12	336	213	32	-	-
9/CT	23	Min.	-	1055	100	35	163	4	341	222	102	-54	-6.1
		Max.	-	4117	625	195	838	31	1683	1751	268	-44	-3.9
		Average	-	2379	265	102	358	16	854	629	156	-48	-5.1
		SD	-	830	126	46	165	6	365	334	38	3	0.7
9/PQ	8	Min.	-	4882	537	219	403	17	1678	750	104	-49	-4.9
		Max.	-	7091	874	350	1448	55	2997	2307	366	-41	-3.2
		Average	-	6104	719	279	881	34	2489	1461	240	-44	-4.0
		SD	-	765	110	41	313	12	361	506	71	2	0.6
10/PQ	23	Min.	6.5	3100	295	318	299	8	1258	532	153	-49	-5.4
		Max.	7.8	9300	1044	923	1195	203	3645	2343	445	-38	-2.7
		Average	6.8	6548	724	640	716	53	2531	1232	257	-46	-4.5
		SD	0.4	1392	164	148	319	41	585	546	79	3	0.6
11/CT	14	Min.	-	3400	289	102	441	16	1393	560	61	-60	-8.1
		Max.	-	7050	717	326	1195	63	2305	1918	281	-39	-5.8
		Average	-	4807	470	191	722	26	1801	1088	148	-52	-7.1
		SD	-	1122	109	63	212	15	291	439	61	6	0.7
11/PQ	14	Min.	-	2550	206	119	306	8	1230	177	85	-52	-7.3
		Max.	-	11400	725	438	1858	55	4558	2187	238	-30	-4.5
		Average	-	5930	450	212	919	22	2351	1062	159	-44	-6.1

Ref. # / aquifer	Number of Samples	Statistic	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	SO_4 (mg/l)	Cl (mg/l)	HCO_3 (mg/l)	δ^2H	$\delta^{18}O$
		SD	-	2631	161	105	481	13	1027	621	47	6	0.9
12/CT	31	Min.	-	642	50	5	212	9	44	257	61	-60	-8.1
		Max.	-	7050	794	357	1715	63	2305	2305	281	6	0.7
		Average	-	3297	391	167	572	20	1115	835	145	-49	-6.4
		SD	-	1711	183	78	305	12	644	471	69	10	1.4
13/CI	111	Min.	6.9	159	22	7	8	3	13	12	10	-67	-9.1
		Max.	8.4	10653	842	596	2280	128	2314	4379	673	-35	-2.2
		Average	7.4	1323	129	66	223	21	388	372	152	-54	-6.1
		SD	0.3	1204	105	65	258	21	368	471	76	7	1.5
14/PQ	84	Min.	6.5	2040	255	95	187	3	1016	212	11	-50	-7
		Max.	8.6	26730	919	1133	5749	150	9263	9051	749	-30	-3
		Average	7.6	8040	625	363	1261	28	3221	1657	203	-45	-5
		SD	0.4	3835	129	178	991	20	1306	1256	113	4	1
Tot/CI	254	Min.	6.7	37	22	7	8	3	13	12	10	-73	-9.2
		Max.	8.5	12705	1007	641	3500	168	4099	5960	673	-35	-2.2
		Average	7.4	1870	236	72	364	35	716	579	142	-56	-7.0
		SD	.3	1410	160	65	343	27	507	627	55	7	1.4
Tot/CT	247	Min.	5.6	13	50	5	76	3	44	119	6	-72	-9.2
		Max.	8.4	8029	960	630	1715	1444	2455	2953	347	-25	-3.9
		Average	7.3	2990	343	132	473	33	1047	800	139	-50	-5.9
		SD	.5	1396	158	71	242	98	459	486	48	6	1.1
Tot/PQ	150	Min.	6.5	2040	206	95	187	3	1016	177	11	-52	-7.3
		Max.	8.6	26730	1044	1133	5749	203	9263	9051	749	-29	-2.2
		Average	7.4	7240	638	369	1061	32	2876	1476	210	-45	-4.9
		SD	.5	3206	154	198	817	25	1136	1030	101	4	1.1

Figures

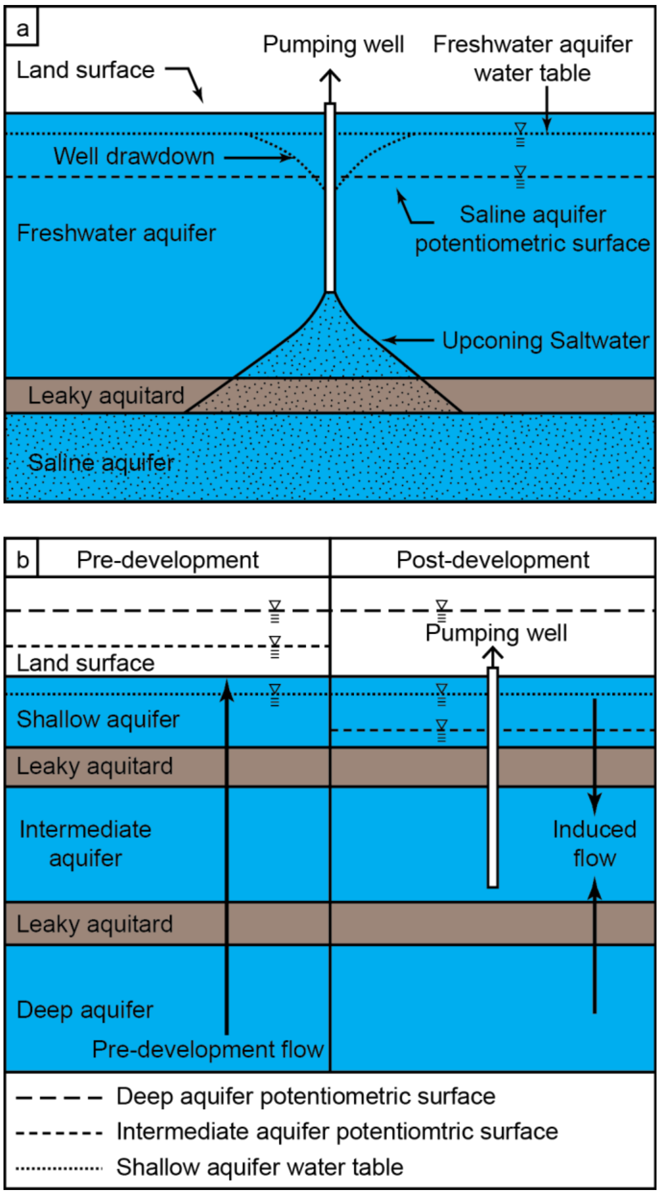
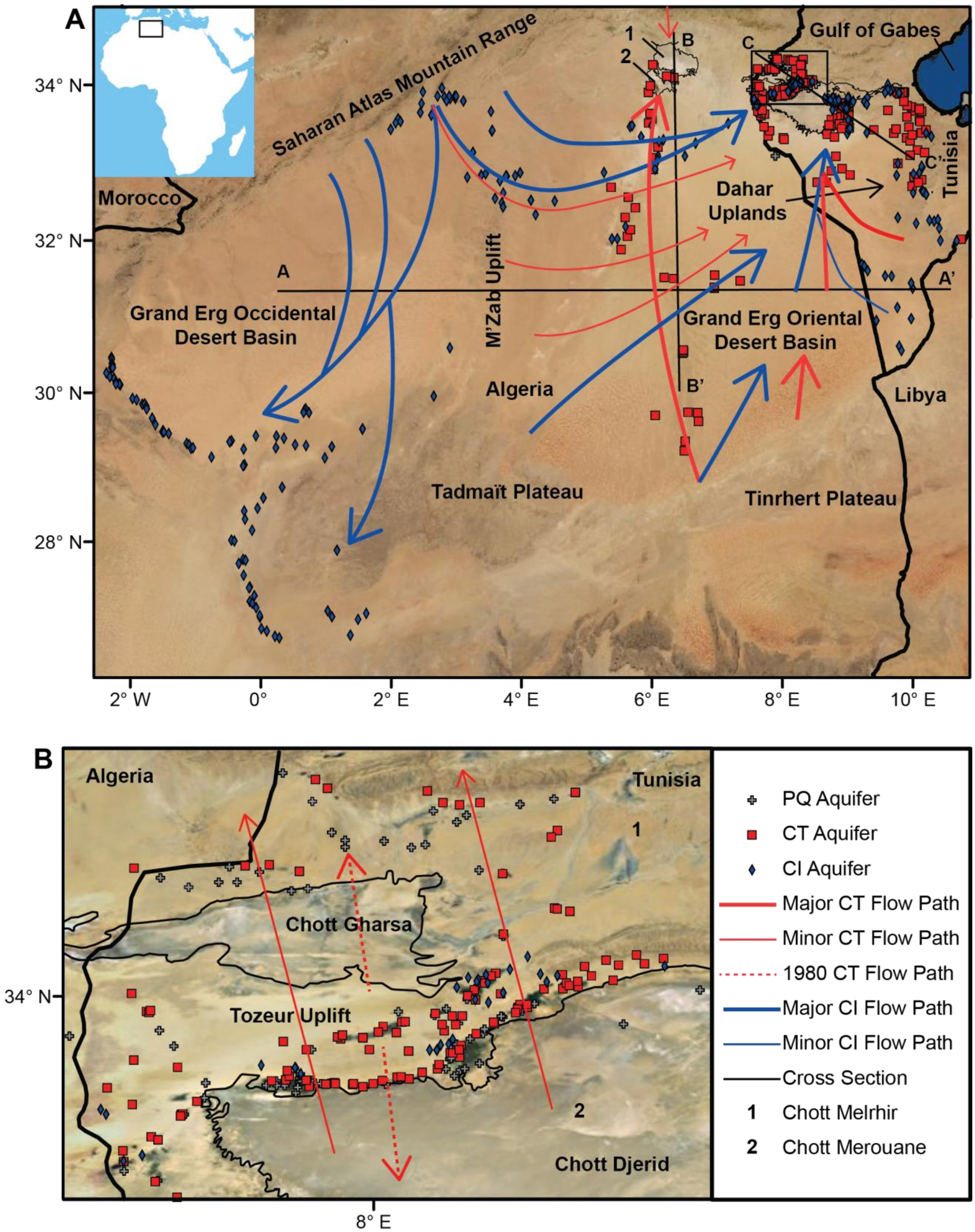


Fig. 1 (a) Illustration of saltwater upconing in a pumped well (b) well development in an intermediate aquifer producing a new induced flow direction.



A
Saharan Atlas Mountain Range
Morocco
Gulf of Gabes
Tunisia
Dahar Uplands
M'Zab Uplift
Grand Erg Occidental Desert Basin
Grand Erg Oriental Desert Basin
Algeria
Libya
Tadmaït Plateau
Tinrhert Plateau
A
A'
B
B'
C
C'
1
2
34° N
32° N
30° N
28° N
2° W
0°
2° E
4° E
6° E
8° E
10° E
B
Algeria
Tunisia
Chott Gharsa
Tozeur Uplift
Chott Djerid
34° N
8° E
PQ Aquifer
CT Aquifer
CI Aquifer
Major CT Flow Path
Minor CT Flow Path
1980 CT Flow Path
Major CI Flow Path
Minor CI Flow Path
Cross Section
1 Chott Melrhir
2 Chott Merouane

Fig. 2 The study area of the North-West Sahara Aquifer System. A) The regional flow area, including the regional flow paths of the CI and CT Aquifers. B) Inset of the Tunisian Chotts region, including the flow paths of the CT aquifer in 1980 and present day.

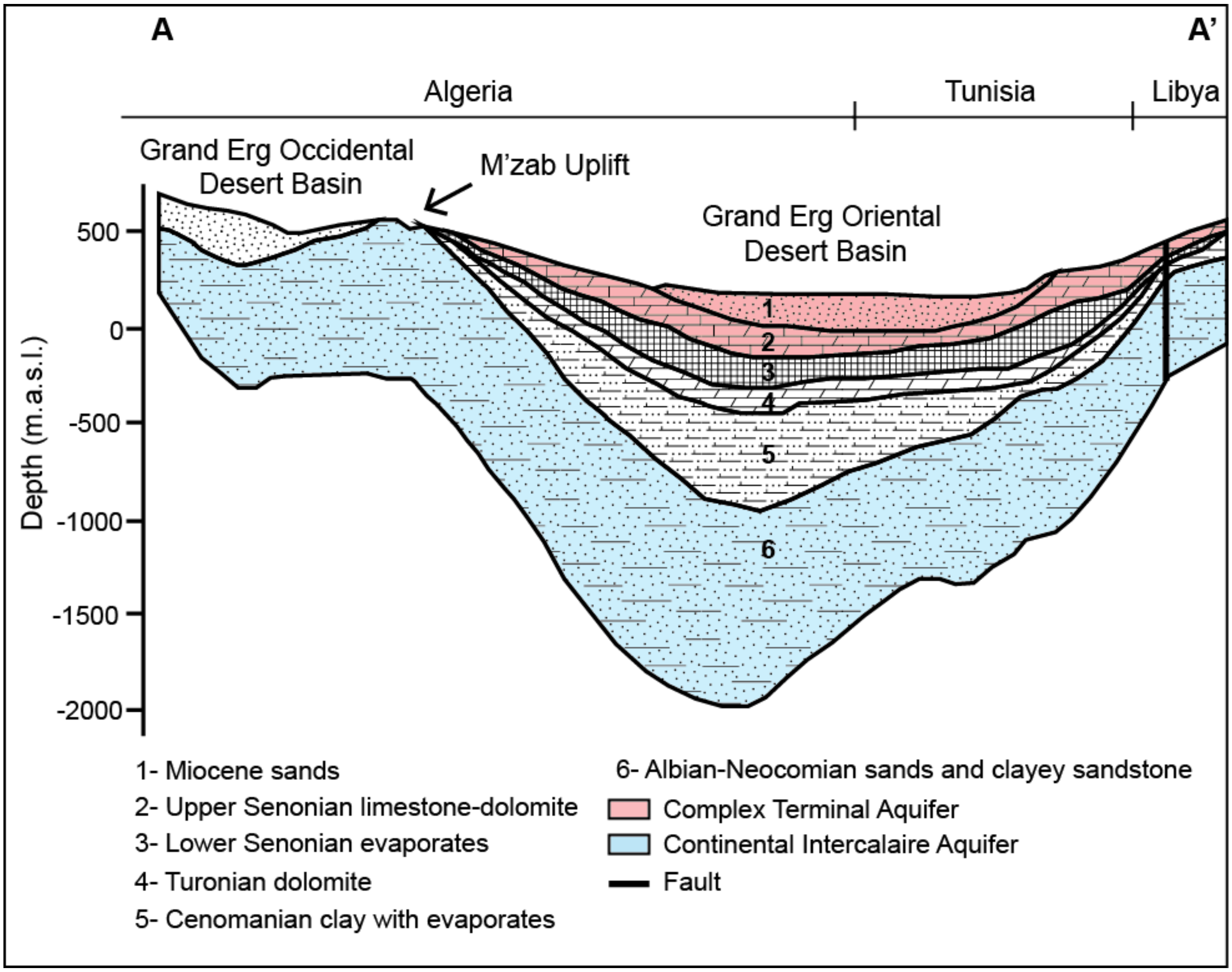


Fig. 3 Simplified East-West cross section of NWSAS, A-A' (modified from Kamel, 2012).

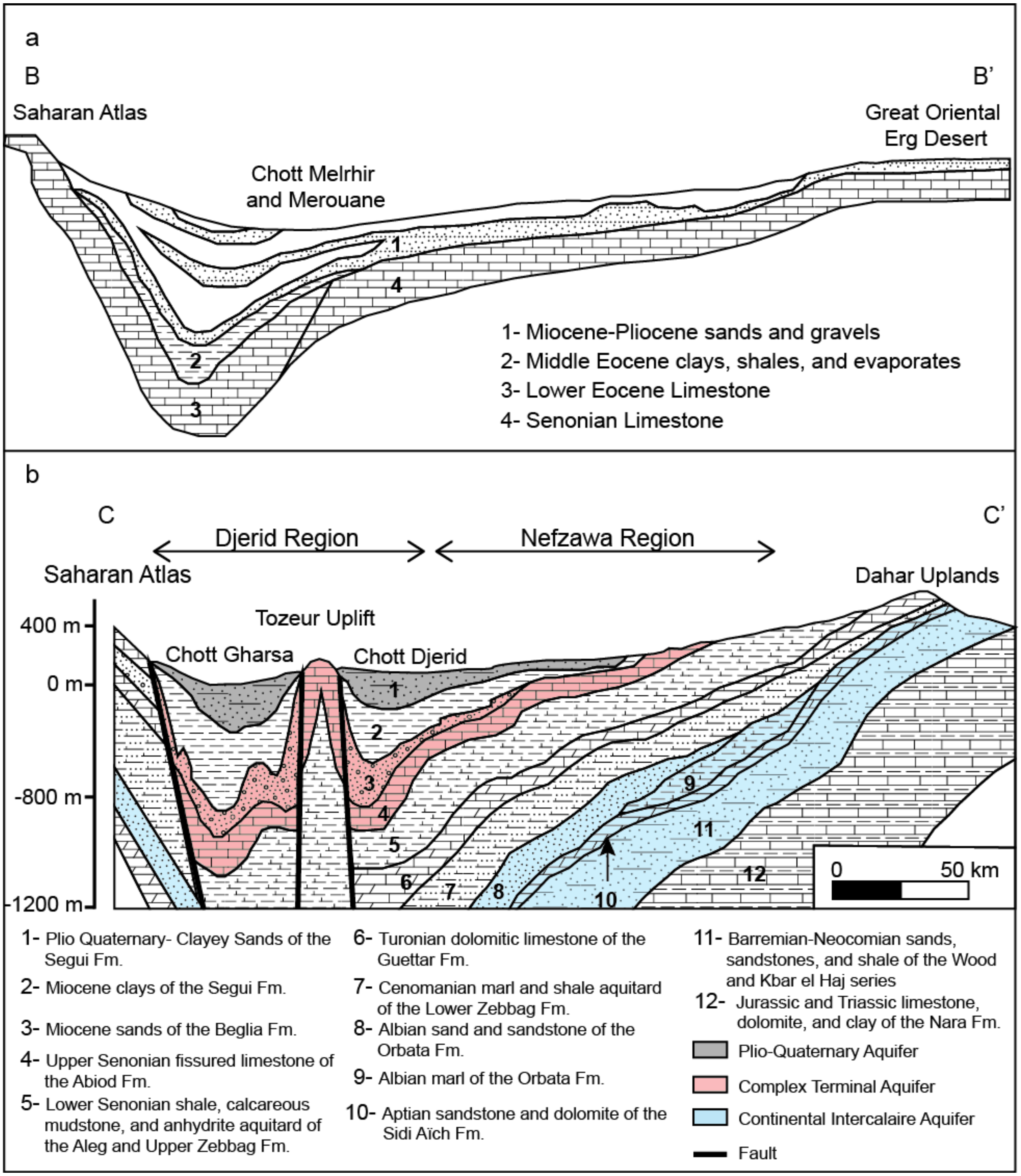


Fig. 4 a) Simplified N-S cross section (B-B') of the CT aquifer in the Oriental Erg Desert Basin b)NW to SE cross section (C-C') through the Tunisian Chotts Region to the Dahar Uplands (Modified from OSS, 2003).

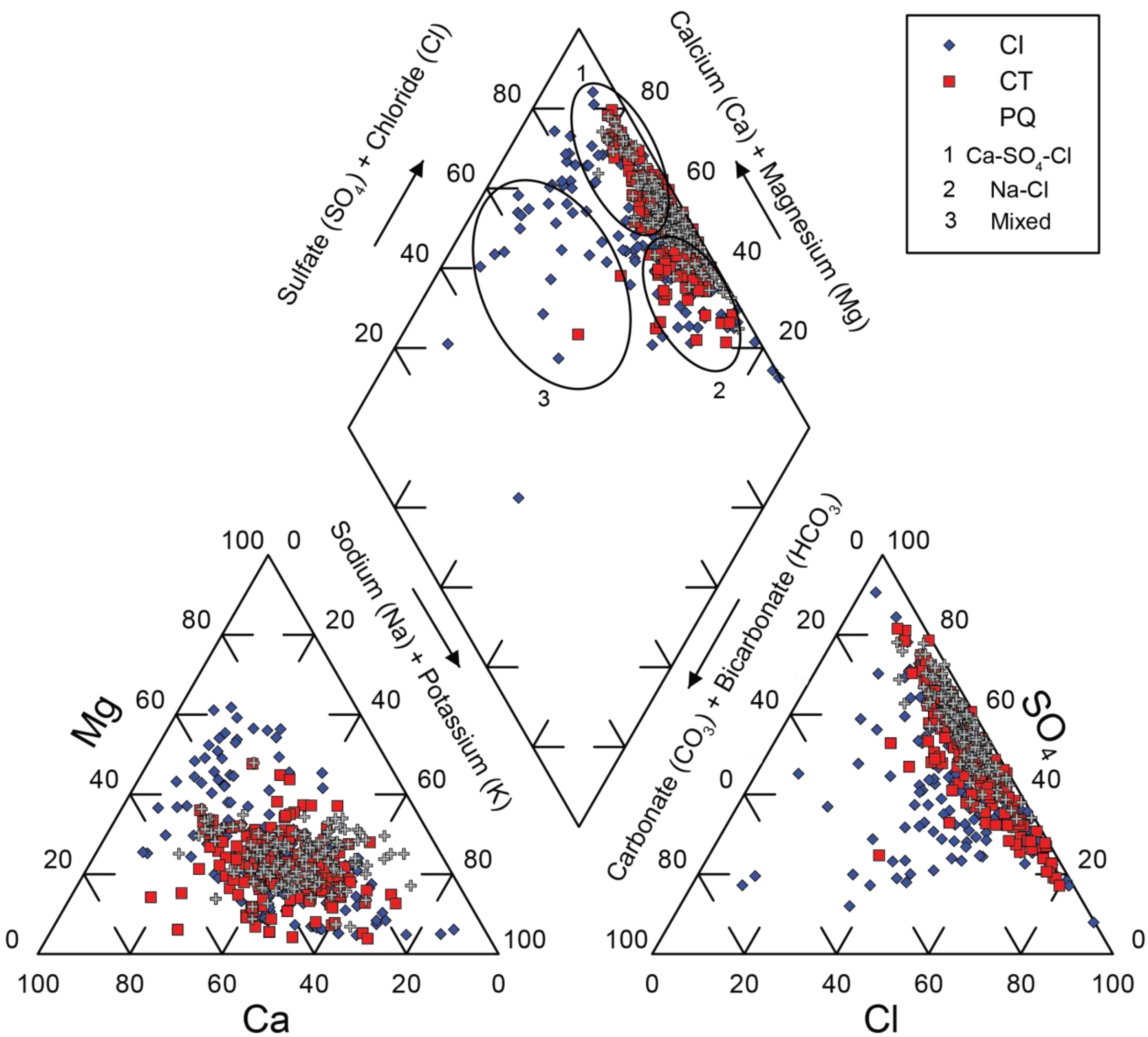


Fig. 5 Piper Diagram of CI, CT, and PQ groundwater showing 1) Ca-SO_4-Cl water type and 2) Na-Cl water type.

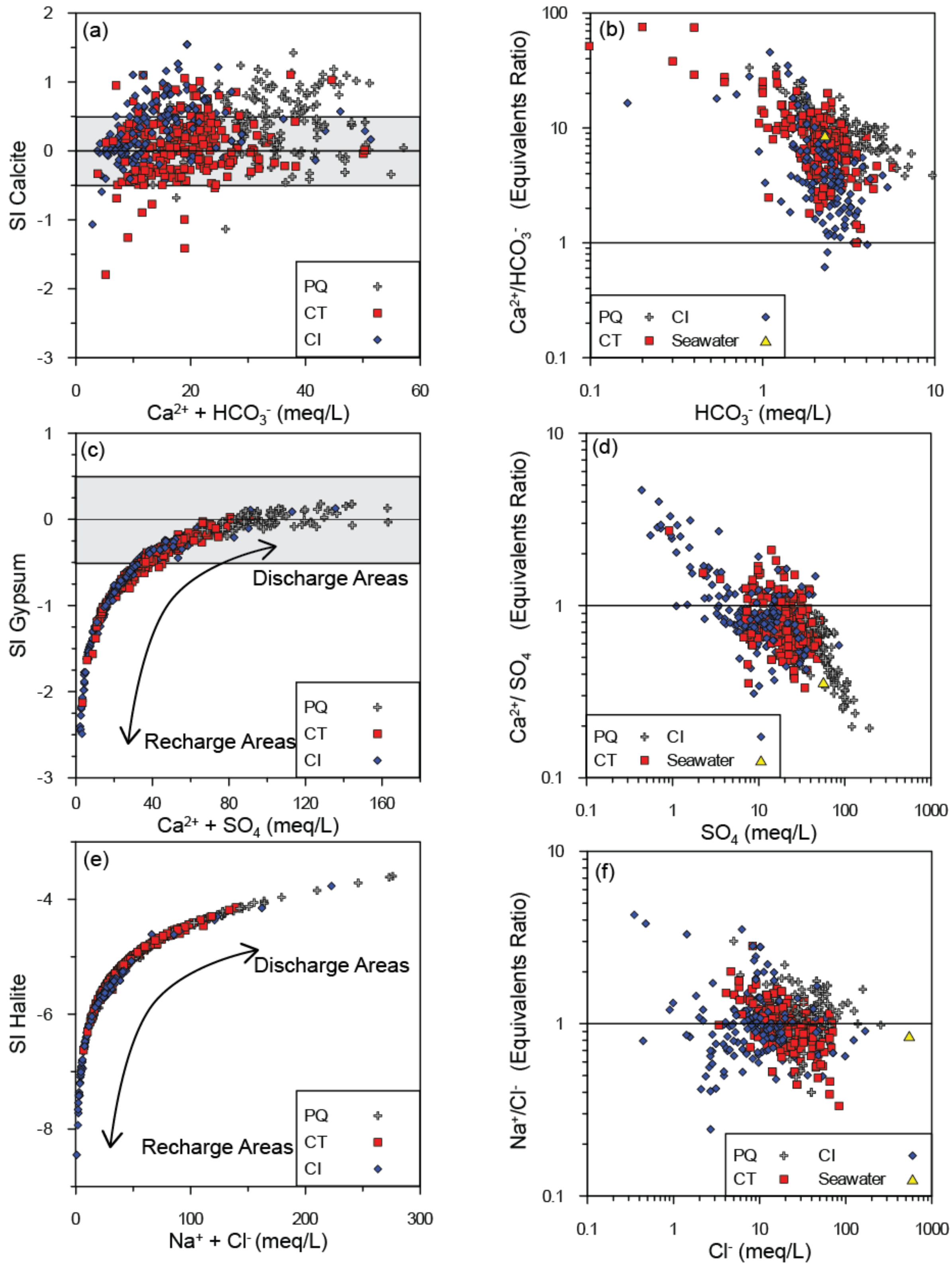


Fig. 6 Saturation indices of calcite, gypsum, and halite, and major ion relationships.

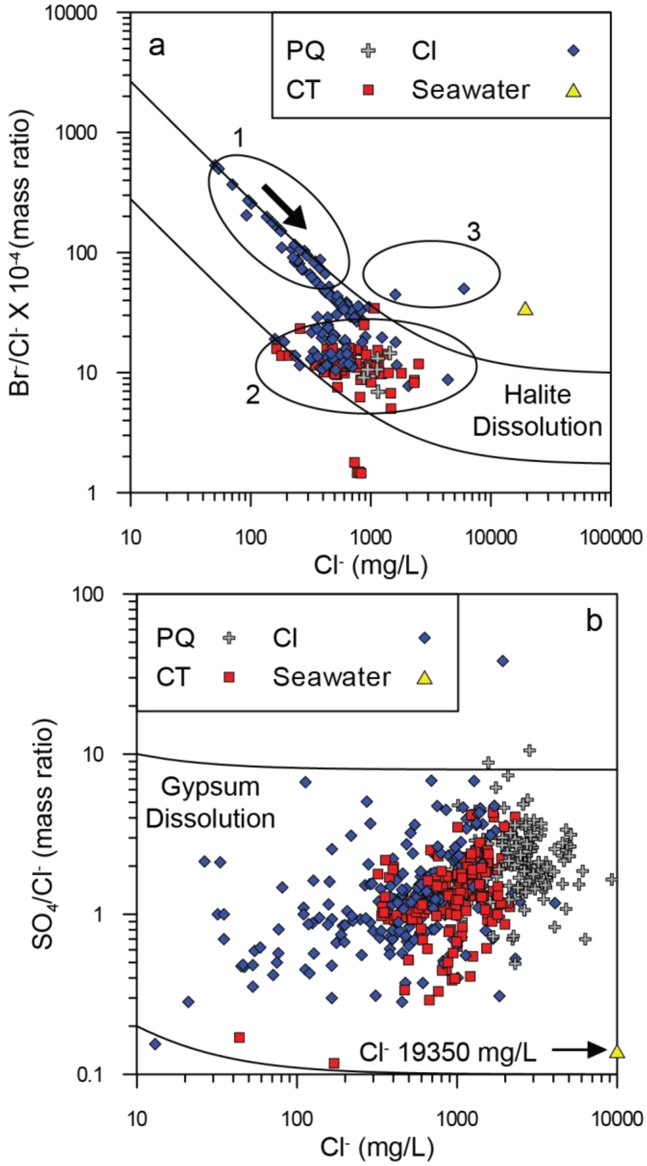


Fig. 7 Graphs of (a) Br/Cl X 10^4 vs. Cl and (b) SO_4/Cl vs. Cl.

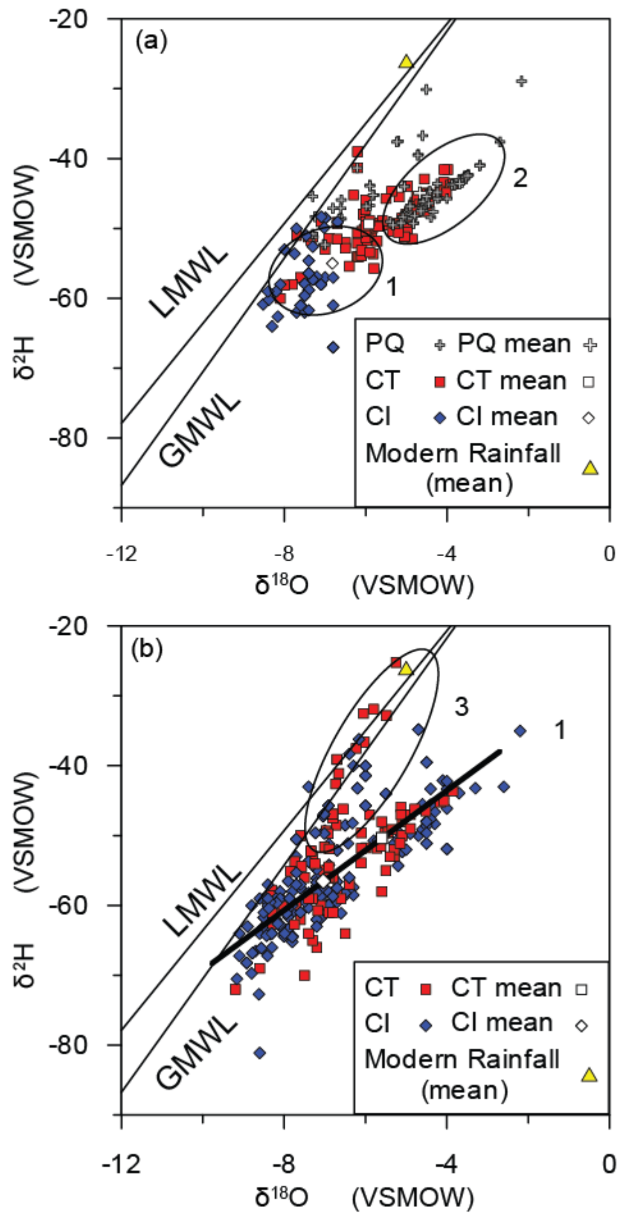


Fig. 8 δ^2H vs. $\delta^{18}O$ (a) Local Tunisian Chotts Region, (b) The regional-flow area data. See text for explanations of numbered ellipses and lines.

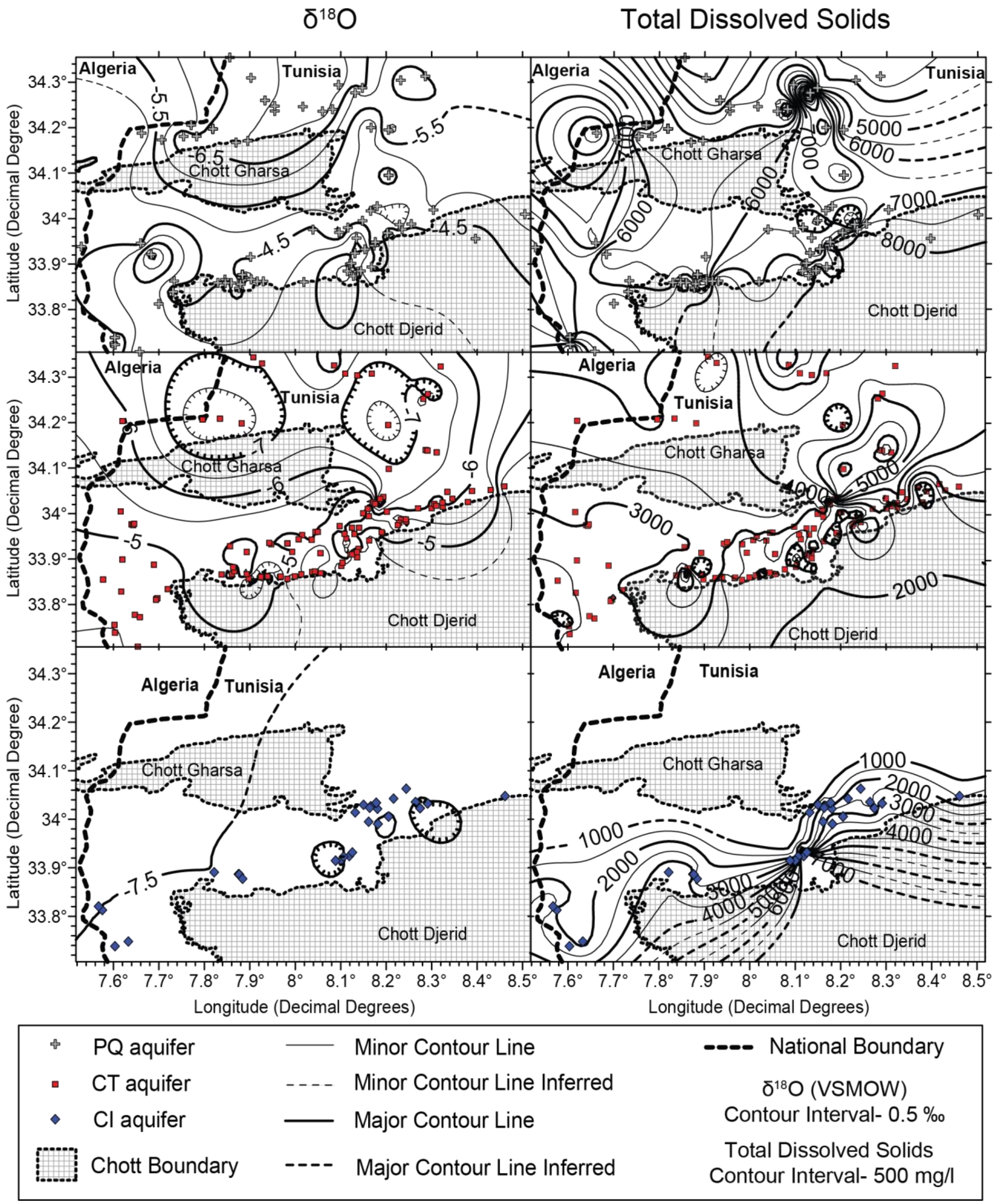


Fig. 9 $\delta^{18}O$ and TDS contour maps of the Tunisian Chotts Region for the PQ, CT, and CI aquifers.

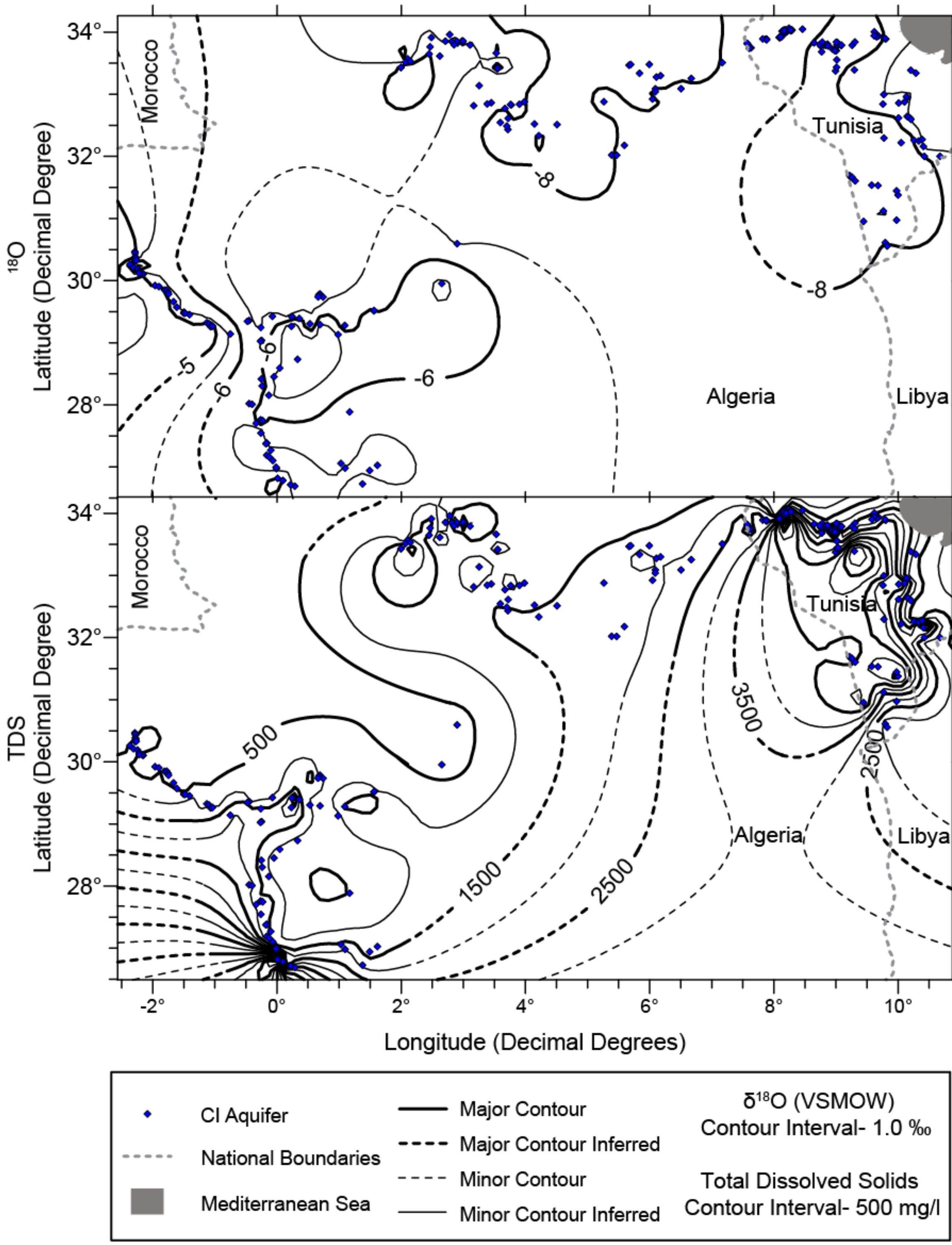


Fig. 10 $\delta^{18}O$ and TDS contour maps of the Continental Intercalaire aquifer.

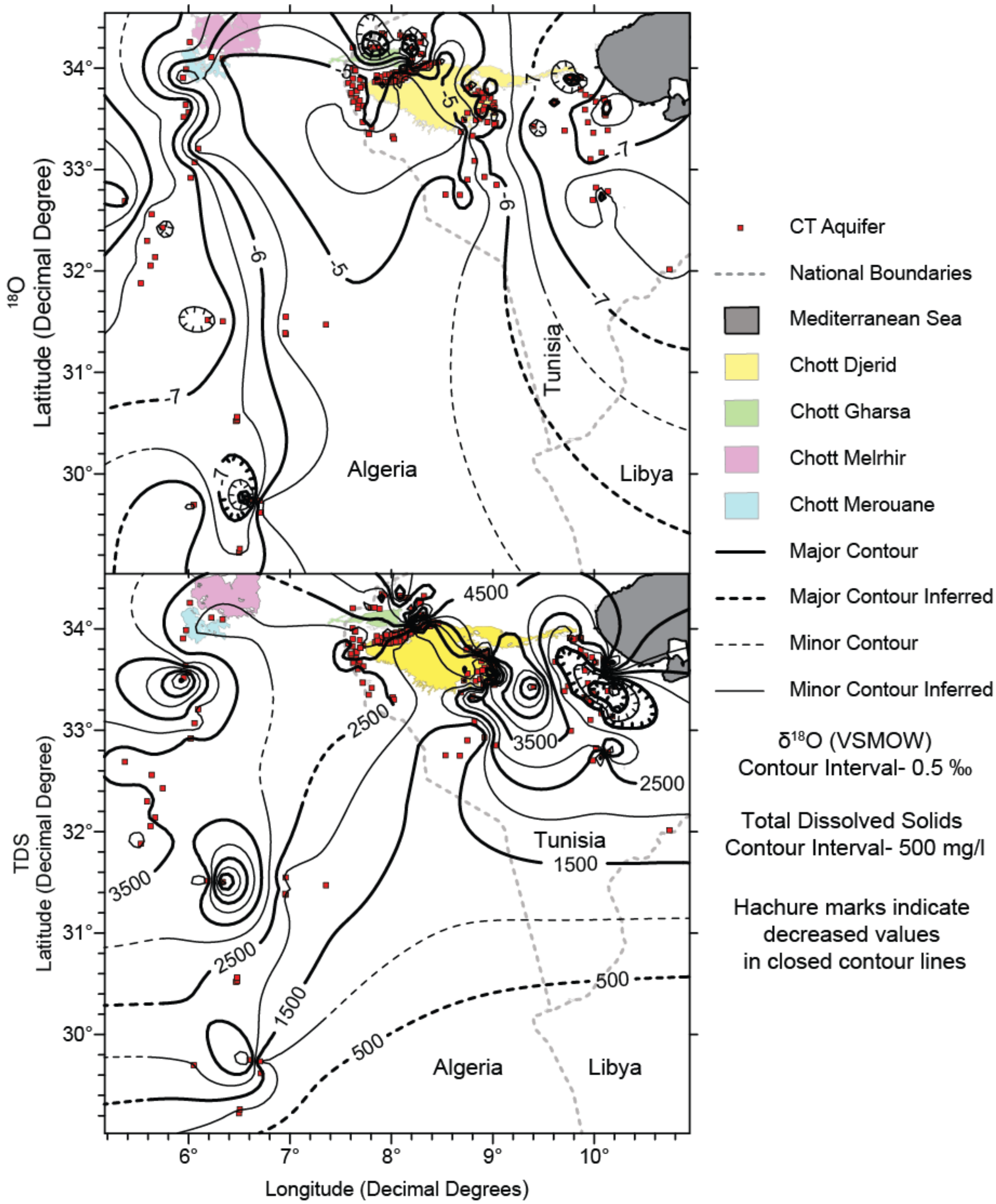


Fig. 11 δ18O and TDS contour maps of the Complex Terminal.

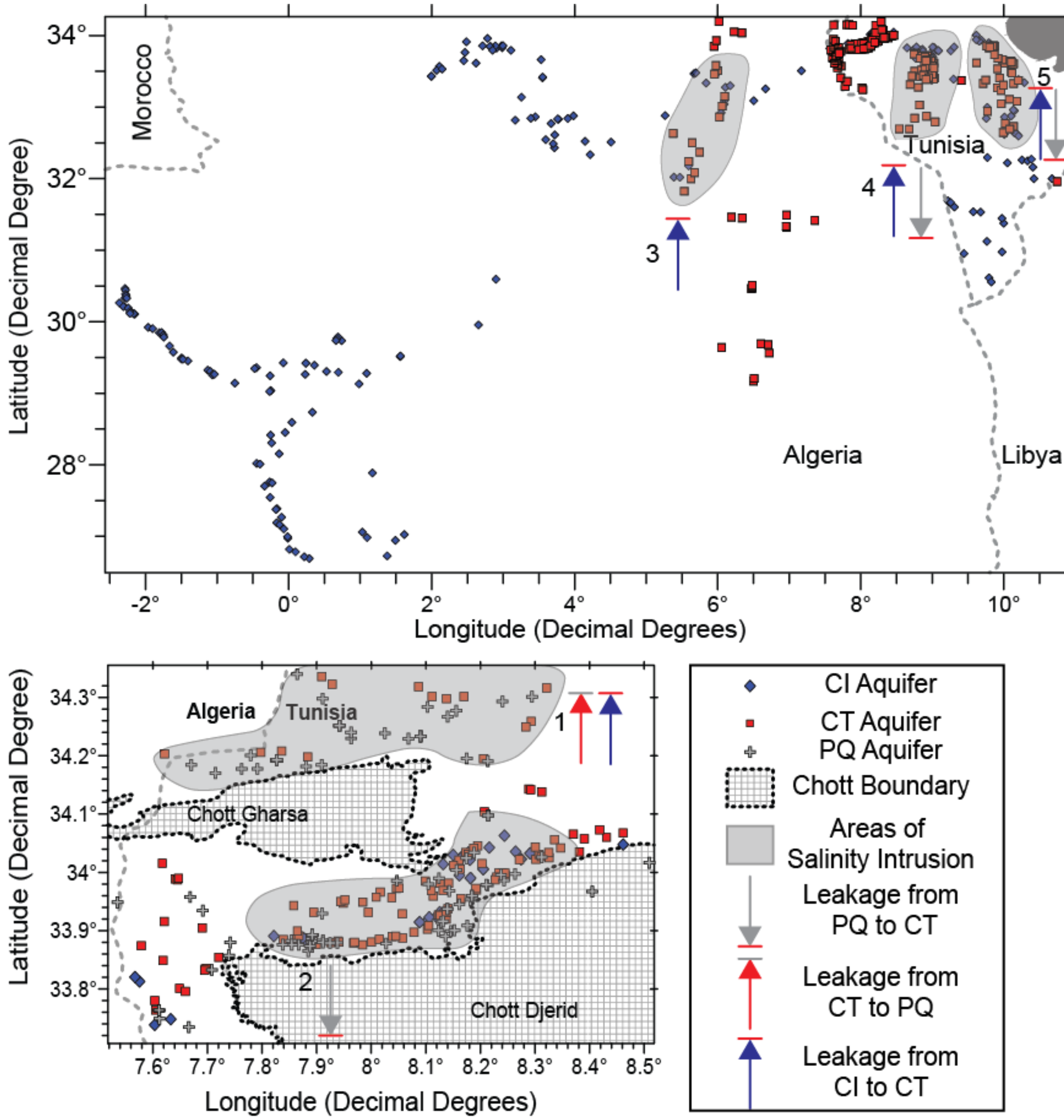


Fig. 12 Map showing the areas (1-5) affected specific processes of salinity intrusion, and with the greatest possibility of future degradation of water quality.

A1- Appendices

Summaries of Data sets

R1- Edmunds et al. 2003 - *Groundwater evolution in the Continental Intercalaire aquifer of southern Algeria and Tunisia: trace element and isotopic indicators*

- Study of CI flow line extending from Algerian Atlas Mountains to Chotts of Tunisia
- The objective was to characterize this flow path to determine hydrogeologic discontinuities, potential recharge, and water-rock interaction
- CI is contained in the Lower Cretaceous (Neocomian, Barremian, Aptian, and Albian)
- The Kébeur el Hadj formation constitutes the aquifer in the Chotts Region
- Along the flow line water temperature increases to 73 °C, chloride increases to 800 mg l^{-1}, and bromide/chloride ratios suggest halite dissolution
- Radiocarbon ages and the $\delta^{18}O$ and $\delta^{2}H$ indicate little modern day recharge and indicate a cooler recharge regime, dated to the late Pliestocene
- Indicated a limit to modern/Holocene water roughly 200 km from recharge are, a redox boundary 350 km from the recharge area, and potential upward leakage to the CT aquifer along the flow path
- Concluded that the flow line is continuous, and the geochemistry is dominated by similar non-carbonate mineralogy

R2- Guendouz et al. 2003 - *Hydrogeochemical and isotopic evolution of water in the Complexe Terminal aquifer in the Algerian Sahara*

- Study area encompasses the Oriental Erg sedimentary basin, highlighting a flow path of the CT aquifer from south to north over 700 km
- The objective was to characterize geochemistry of the flow path, investigate recharge and relative age of the groundwater, and determine overall potability
- Oriental Erg is formed by a E-W striking syncline with an extended southern limb
- The CT is housed within the Mio-Pliocene sand and the late Eocene and early Senonian carbonates of various thicknesses and lithology dependent upon location
- Samples collected from 1994-1996
- Along the flow line (recharge in the Tinrhert Plateau and discharge in the Algerian Chotts) the TDS increases to 8 g l^{-1}
- Bromide/chloride ratios and strontium isotopes suggest dissolution of halite and gypsum as primary contributors to TDS
- In the south among the Amguid faults upward leakage from the CI is possible

- The isotopic signature indicates evaporative enrichment of rainwater, and a few points deviate from the isotopic mean
- The first 400 km are considered Holocene in age and late Pleistocene after
- Along the flowpath significant water rock interaction is taking place as evidenced by the increase in most major ions
- The CT groundwater is considered to be a non-renewable resource with borderline quality

R3- Kamel et al. 2005 - *Geochemical and isotopic investigation of the aquifer system in the Djerid-Nefzaoua basin, southern Tunisia*

- Study area comprises the Djerid-Nefzaoua region (Tunisian Chotts), and highlights the PQ, CT, and CI aquifer
- The objective was to use major and minor ion chemistry and isotopes to identify water migration pathways and water-rock interactions
- The PQ is hosted in un-named sands and clays with gypsum
- The CT is hosted in the Miocene unit in the Beglia and Segui sand and clay formations, as well as the Senonian unit in the Abiod fissured limestone formation
- The CI is hosted in the several units including the Hautervanian-Barremian unit in the Boundinar clayey sandstone formation and Kbar el Haj series, in the Aptian unit in the Sidi Aïch sands and sandstone formation, and lastly the Aptian-Albian unit in the Orbata sandstone, limestone, and marl formation.
- Samples collected in August of 1999
- Contains a table highlighting the stratigraphic units and Geologic formations in the area
- The TDS values of each aquifer from highest to lowest are PQ, CT, CI
- Confirms that mineralization is due to dissolution of halite, gypsum, and calcite, and indicates sulfate enrichment relative to calcium possibly due to pyrite oxidation, or cation-exchange.
- The isotopic studies indicate that upward leakage into the CT from the CI is occurring, CT water is mixing with evaporated return flow waters through downward leakage, and CT and PQ water are mixing with modern day recharge
- Concludes that water pumped from the CT aquifer is used as flood irrigation water, seeping into the PQ aquifer after evaporative concentration and dissolution of evaporitic rocks, subsequently leaking into the CT

R4- Abid et al. 2012 - *Deciphering interaction of regional aquifers in Southern Tunisia using hydrochemistry and isotopic tools*

- Study area encompasses the Dahar Uplands, extreme south(Tunisia), and the Gulf of Gabes through Tunisian Chotts region, investigating the CI and CT aquifer
- The objectives of this study were to utilize geochemistry and isotopic tools to understand the Turonian formation of the CT and how it relates to the CI in the southern Tunisia

- The samples were collected from January to April of 2004
- Both the CI and CT exhibit wide ranges in TDS (500 – 8000 mg l^{-1})
- Dissolution of evaporites confirmed by PHREEQC, principal component analysis, and general TDS/ion trends
- TDS values are low in the Dahar Uplands, and are high in the near the Chotts and the tectonic zone of Gabes
- The calcium-sulfate graph indicates incongruent dissolution of gypsum
- Stable isotope investigation indicates CT water mixing with both recent infiltration and with CI paleowater
- The CT in the El Hamma region could be highly influenced by the CI
- The super saturation of calcite and dolomite is explained by geogenic CO_2, producing high partial pressure of CO_2, from deep tectonic faults and discontinuities

R5- Kamel et al. 2008 - *The hydro geochemical characterization of ground waters in Tunisian Chott's region*

- Study area encompasses the Chotts region (Djerid and Gharsa) investigating the CI, CT, and PQ
- The objectives of this study are re-examine the processes contributing to groundwater mineralization in the region
- Samples were collected in June 2003
- The PQ is hosted in the Clayey Segui formation
- The CT is hosted in the Upper Cenomanian Zebbag formation in the Ghafsa region, Upper Senonian Aboid formation in the Kebili region, and the Tertiary Beglia formation near Tozeur
- In this region the CI is hosted in the Bou Dinar formation, and the Sidi Aïch formation
- Two groundwater types Na-Cl and Ca-SO4-Cl
- Evidence of halite and gypsum dissolution from bivariate plots and saturation indices
- Depletion of Ca probably due to carbonate precipitation
- Sfax, Tunisia mean isotopic composition of rainfall- -4.6 $\delta^{18}O$ and -23.3 $\delta^{2}H$
- Hypothesized that trend line on $\delta^{2}H$ vs $\delta^{18}O$ plot is not mixing line, but evaporation line
- CT is enriched by rainfall with heavier isotopic signature
- ^{14}C data indicates Pliestocene age CI water and late Pleistocene to Holocene age CT water

R6- Tarki et al. 2011 - *Geochemical and isotopic composition of groundwater in the complex terminal aquifer in southwestern Tunisia with emphasis on the mixing by vertical leakage*

- Study area encompasses the Chotts region (Djerid and Gharsa), investigating the CT

- The objectives of this study were to investigate hydrodynamic changes caused by over-pumping, determine the principal processes of mineralization, and determine significance of modern day recharge

- Samples collected in December 2006

- CT is hosted in the Tertiary sands of the Beglia formation in the Burdigalian-Langhian unit in the Djerid region and in the Upper Senonian of the Berda formation in the Nefzaoua region

- CT has undergone 40-30 m drops in piezometric head, with flow now moving south to north

- Long term pumping of CT causes loss of potentiometric pressure, favored upward leakage along faults, and enhanced downward leakage to CT from PQ evidenced by isotopic compositions

- Water chemistry determined by dissolution of halite and gypsum, as well as pyrite oxidation evidenced by bivariate plots

- No link between temperature and the screened interval, and EC and TDS not homogeneous-possibly due to leakage from above/below

- Chadha diagram shows two groundwater groups alkaline earths rich(Na-Cl type) and alkali metals rich(Ca-Mg-SO_4/Ca-Mg-Cl type)

- Shallow wells show mixing with the PQ and the Deep wells show mixing with the CI

- Provides map of $\delta^{18}O$ across study area to highlight where mixing is occurring

- Conclude with remarks highlighting aquifer mixing from above and below the CT

R7- Abid et al. 2010 - *Identification and characterization of hydrogeological relays of Continental Intercalaire aquifer of southern Tunisia*

- The study area covers the Dahar Uplands, Tunisian Chotts region, and the area near the Gulf of Gabes

- The objectives of the study are two investigate the mineralization of the aquifer, determine hydrologic connections, and determine the extent of modern recharge

- Samples collected in January to April 2004

- Provides five boreholes with stratigraphic correlation between them with details from several sections

- The CI is hosted in various formations including the Sidi Aïch sandstone, the Bou Dinar sandstone, the Kebar el Hadj sandstone, and the Albian Sandstone

- Well temperatures, conductivity, and TDS increase from recharge to discharge zones

- Utilizing the data from major ion chemistry the authors conclude that calcite is precipitated and halite and gypsum are potentially dissolved

- Presents the data as a flow path from the Dahar Uplift to the Chott Fedjej region

- Posits that in the El Hamma fault zone upward leakage is occurring

- δ^2H vs $\delta^{18}O$ plot indicates leakage into the overlying CT aquifer
- Authors conclude that mixing is possible near the El Hamma fault zone, with no comments on the source of salinity besides evaporite dissolution

R8- Kamel, S. 2012 - *Application of selected geothermometers to Continental intercalaire thermal water in southern Tunisia*

- The study covers the Tunisian Chotts region, investigating the geothermal nature of the CI
- The objective of this study was to estimate the temperature of the CI water using various geothermometers
- Provides a borehole analysis showing all of the units in a simplified stratigraphic column
- In this column the CT is recognized in the Beglia formation and the CI in the Sidi Aïch formation
- Analysis done on geochemical data points selected from the Avicenne project database in the Chotts area
- Utilized a Na-K-Mg geothermometer, Na-Li geothermometer, and a multiple mineral equilibrium approach to asses geothermal potential near the oasis

R9- Kamel et al. 2006 - *Hydrogeological and hydrochemical approach of hydrodynamic exchanges between deep and shallow aquifers in the Djerid basin (Tunisia), in French*

- The study area focuses on the Tunisian Chotts region, investigating the CT and PQ aquifers
- The objective of the study was to identify processes affecting salinization
- The samples were collected in June of 1999
- The CT aquifer is hosted within the Upper Senonian and the Miocene formations
- The PQ aquifer is hosted in the Segui formation
- Using bivariate plots the authors hypothesize dissolution of halite and gypsum, and show that cation exchange with magnesium and sodium is causing the deficiency in calcium
- δ^2H vs $\delta^{18}O$ plot indicates an evaporation line with return flow mixing into the PQ and subsequently the PQ water mixing with the CT
- ^{14}C values corroborate the idea of newer water in the PQ mixing with the older CT water
- Concludes that the increases in salinity are directly related to piezometric levels, for example the lower head levels have higher salinity

R10- Tarki et al. 2012- *Groundwater composition and recharge origin in the shallow aquifer of the Djerid oasis, southern Tunisia: implications of return flow*

- Study area encompasses the Tunisian Chotts region, investigating the PQ
- The objective of this study was to investigate the possibilities of salinity intrusion by agricultural return flow, the chott brine, and dissolution of evaporites
- PQ sampled in 2011

- Provides an overview of the Tunisian Chotts area stratigraphy, reaching from the Jurassic to the Quaternary
- States that more water is infiltrated from flood irrigation than by natural recharge to PQ
- Provides model of PQ salinization from irrigation return flow
- Explains the concept of PQ aquifer mineralization by evaporative concentration of irrigation return flow
- The authors hypothesize that the groundwater in the area beneath the chotts in highly mineralized and that the flow gradient is toward the saltwater-freshwater interface
- It is hypothesized that the reason for the low calcium to sulfate ratio is due to epsomite dissolution
- The authors conclude that fossil water of the CT and PQ are mineralized due to irrigation practices in the oases, and by dissolution of evaporites

R11- Yangui et al. 2012 – *Deciphering groundwater flow between the Complex Terminal and Plio-Quaternary aquifers in Chott Gharsa plain (southwestern Tunisia) using isotopic and chemical tools*

- The study area is north of Chott Gharsa, investigating the CT and PQ aquifers
- The objective of the study was to characterize the relationship between the CT and PQ in the Chott Gharsa plain
- Samples collected from 2003 to 2004
- The CT is hosted in the Miocene age, Beglia formation; the PQ is hosted in the Segui formation
- In this area the CT is considered to be mostly semi-confined by a layer of clays
- North of Chott Gharsa the PQ is recharged by upward leakage from the CT
- The groundwater generally flows from north to south
- It is unclear whether the aquifer system is not in steady state with respect to cation exchange due to anthropogenic influence (groundwater exploitation) or due to remnants of a freshening phase from the last marine transgression
- Tritium, radiocarbon, and stable isotope analyses agree that the CT aquifer is Pleistocene in age
- Stable isotope analyses also reveal CT and PQ mixing with modern day recharge as well as PQ and CT mixing from both upward and downward leakage
- Calculated the percentage of CT water in the PQ sampled based on δ^2H vs $\delta^{18}O$ values
- Toward the eastern edge of the study area, less CT water constitutes the PQ
- The authors conclude that the complex nature of the stratigraphic and tectonic activity play a large role in aquifer salinization

R12- Zammouri et al. 2007- *Salinization of groundwater in the Nefzawa oases region, Tunisia: results of a regional-scale hydrogeologic approach*

- Study area is SW of Chott Djerid in the Nefzawa oases, investigating the CT

- The objective of the study was to determine the cause of CT groundwater salinization
- The samples were collected in 2002
- Provides water abstraction data in the region and discusses increases in illicit abstraction
- Possible salinization sources include brine intrusion from Chott Djerid, upconing of saltwater from the CI, and seepage of agricultural drainage water
- The CT in this region is comprised of the Upper and Lower Senonian, the sandy formations of the Eocene, and the Mio-Pliocene sands
- The Cenomanian shales divide the CT and CI aquifers and the CI is hosted in the Triassic to the Albian
- The Turonian aquifer could be a potential source of salinity in this region due to upconing in the CT wells
- Provides evidence of TDS increase in the region
- Summarizes that the Chott brine is not a source of salinity
- Attributes the increase in salinity in the CT in the southern region to downward percolation, and in the north to upward leakage
- Constructed a flow and transport model of the study area and include all three aquifers
- Transport model indicates that current pumping regime should be lessened in order to decrease the changes in salinity

R13- Moulla et al. 2012- *Updated geochemical and isotopic data from the Continental Intercalaire aquifer in the Occidental Erg sub-basin (southwestern Algeria)*

- The study area is located in the Occidental Erg, investigating the CI aquifer
- The objectives of the study were to collect geochemical and isotopic data in order to characterize aquifer characteristics such as recharge, mixing, and residence time
- Samples were collected from 2003 to 2005
- The CI is housed in the lower Cretaceous, Albian unit and is generally unconfined
- There is a deep saline aquifer beneath the CI in this basin
- The CI aquifer flows from north to south in this area and is pinched as it flows south
- Bivariate plots of sodium vs. chloride and calcium vs sulfate, indicate dissolution of halite and gypsum
- The CI is generally isotopically enriched in the Occidental Erg Desert Basin compared to the Oriental Erg Desert Basin
- The isotopic investigation reveals an evaporation line linked to the overlying Erg aquifer in the western portion of the aquifer, and indicates modern day recharge in the Saharan atlas mountain range

R14- Kamel, S. 2013 - *Salinization origin and hydrogeochemical behavior of the Djerid oasis water table aquifer (southern Tunisia)*

- Study area encompasses the Chotts region (Djerid and Gharsa), investigating the PQ aquifer
- The objective of the study was to understand the recharge and mineralization of the PQ aquifer in the Djerid region
- The samples were obtained from wells 5 to 50 m in depth, between 2007 and 2011
- Defines the chotts as evaporative pumps at center and edges of basins
- The CT is hosted in Upper Cretaceous and Miocene formations
- At the base of the PQ a compact clay confines the CT
- Usual depth of PQ from 10 to 40m in oasis region and north of Gharsa up to 400m
- PQ flow moves from Tozeur uplift and discharges in chotts
- Fluctuation in PQ groundwater level are controlled by balance of artesian recharge and evaporation
- Chott brine may leak into PQ
- Large extension of agricultural areas contributes to drying up of springs and a decrease in PQ water quality due to crust formation.
- Crust dissolves by return irrigation flow and precipitation influencing the chemical composition of the PQ
- Isotopes show three groups: 1) PQ water affected by direct infiltration and upward leakage outside oasis area. 2) Recharge by upward leakage and irrigation return flow in oasis area. 3) recharge by upward leakage and return flow in oasis limits
- The authors conclude that over pumping has ended artesian conditions and increased connection between the PQ and CT aquifers and contributed to increased salinity

Supplementary Tables- Appendix B

Sample table of Authors various hypotheses of the Ca-HCO_3-SO_4 system

Author	Cation Exchange	Incongruent Dolomite Dissolution	Epsomite Dissolution	Pyrite Oxidation	CO_2 Outgassing
Abid et al., 2012	x	x			x
Abid et al., 2010	x	x			
Edmunds et al. , 2003	x	x			
Guendouz et al., 2003	x	x			
Kamel, 2013	x	x			
Kamel et al., 2005	x			x	
Kamel et al., 2006	x	x			
Kamel et al., 2008		x			
Tarki et al., 2012	x		x		
Tarki et al., 2011	x			x	
Yangui et al., 2012	x	x			

Table 3 Location, aquifer type, and field data of the NWSAS

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
1	1	1	Bouheraroua	32.4319	3.7167	CI	390	29.1	7.23	2460	1618
2	1	2	Bensmara 1	32.4875	3.6997	CI	371	30	7.14	2250	1431
3	1	3	Daia Ben Dahoua	32.5447	3.5950	CI	467	31.6	7.41	2350	1534
4	1	5	El-Assafia 1	33.9611	2.7806	CI	100	20.6	7.32	1650	1181
5	1	6	Djebel Makrane (U1)	33.7639	2.4653	CI	210	29.1	7.28	2810	2166

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
6	1	7	Hassi-Dalaa	33.6625	3.5306	CI	350	29.4	7.27	2130	1383
7	1	8	Berriane 2	32.7711	3.6700	CI	545	28.6	7.56	1500	964
8	1	9	Laroui	32.8778	3.9833	CI	650	28.6	7.44	1860	1213
9	1	10	Guerrara: Laameyed	32.5111	4.5086	CI	1000	37.4	7.44	2500	1548
10	1	12	El-Mir	32.8806	5.2639	CI	1895	50.8	7.6	2850	1767
11	1	14	Blidet Omar 1989	32.9222	6.0472	CI	1800	46.5	7.61	2750	1813
12	1	16	Ain-Sahara	33.0875	6.0917	CI	1799	50.5	7.51	3000	1968
13	1	17	Sidi-Slimane 1	33.2764	6.1083	CI	1776	51.7	7.57	2940	1973
14	1	18	Sidi-Slimane 2	33.2994	6.1750	CI	1775	54.7	7.38	2910	1952
15	1	20	Meggarine	33.3375	5.8375	CI	1820	53.7	7.39	3460	2282
16	1	22	Ain-Choucha	33.4806	5.9944	CI	1755	46.5	7.82	2630	1719
17	1	37	Etteibat	33.0889	6.5042	CI	1890	55.2	7.62	3210	2167
18	1	38	Sehane El Berry	33.5083	7.1694	CI	850	35.9	7.8	3490	2449
19	1	39	El Oued	33.2556	6.6694	CI	1850	55.7	6.93	2960	2045
20	1	40	Sidi-Mahdi	33.0397	6.0897	CI	1750	37.9	7.49	2820	1953
21	1	42	Khchem Er'rih	32.1778	5.5931	CI	1450	48.5	7.58	2650	1745
22	1	45	Hassi Ben Abdelleh 3	32.0208	5.3875	CI	1400	49.6	7.82	2700	1700
23	1	47	Hassi Ben Abdelleh 4	32.0186	5.4694	CI	1450	48.9	7.6	2630	1595
24	1	49	Zelfana 1	32.3344	4.2158	CI	1000	37.8	7.59	2800	1631
25	1	50	Zelfana 8 (Fedj Enaam)	32.5222	4.1444	CI	950	34	7.72	2290	1415
26	1	78	M'rara MR3	33.4669	5.6678	CI	1700	47.5	7.2	2720	1624
27	1	79	M'rara MR4	33.4797	5.6933	CI	1680	48	7.29	2730	1667
28	1	101	Nefta CI 1	33.8868	7.8753	CI	2068	70	7.34	5130	3368
29	1	102	Nefta CI 2	33.8863	7.8767	CI	2326	72	7.17	4700	2717
30	1	103	Tozeur CI 1	33.9241	8.1188	CI	1730	67	7.16	24400	12705
31	1	104	Tozeur CI 2	33.9147	8.1003	CI	1757	68	7.33	5880	3334

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
32	1	105	Tozeur CI 3	33.9147	8.0887	CI	1885	66	7.13	4200	2519
33	1	106	El-Hamma C I2	33.9902	8.1818	CI	1469	64	8.2	5030	3377
34	1	107	El-Hamma C I4	34.0056	8.2052	CI	1339	73	7.57		3191
35	1	108	Tazrarit CI 1	34.0326	8.2911	CI	2052	68	8.52	5650	3362
36	1	109	Cedada CI 2	34.0227	8.2744	CI	2257	38	7.11		2510
37	1	110	Chorfa CI 4	33.7882	8.8324	CI	2042	70	7.18	4440	2180
38	1	111	Zouia CI 5	33.7904	8.8041	CI	2052	71	7.24	4360	2271
39	1	112	Mansoura CI 3	33.7266	8.9432	CI	1700	52	7.57	4940	3346
40	1	113	Mansoura CI 13	33.7329	8.9872	CI	2368	65	7.74	3680	2178
41	1	114	Kebili CI 10	33.7009	9.0071	CI	2286	66	7.55	3930	2311
42	1	115	Kebili CI 16	33.6824	8.7694	CI	2578	70	7.2	3130	2138
43	1	116	Taouargha CI 2	33.7873	9.2591	CI	900	45.5	7.2	3130	2244
44	1	117	El Bhaier CI 9	33.7860	9.0849	CI	1268	65	7.17	3460	2421
45	1	118	Limagues CI 8	33.7792	8.7523	CI	1568	67	7.3	3340	2317
46	1	119	Debabcha CI 14	33.8021	8.7362	CI	2159	71	7.07	4640	2167
47	1	120	Souk El Ahad CI 17	33.8067	8.8631	CI	2100	68	7.35	2830	1827
48	1	121	Menchia CI 6	33.7837	9.0313	CI	2178	72	7.04	3640	3037
49	1	122	Seftimi	33.8017	9.0170	CI	1666	72.5	7.54	3250	2258
50	2	11	El-Alia	32.6889	5.3722	CT	160	29.4	7.49	4320	3162
51	2	13	DASE	32.5597	5.6367	CT	100	27	8	4900	3390
52	2	15	Blidet Omar 1964	32.9194	6.0208	CT	168	24.4	7.25	5190	3405
53	2	19	Sidi-Slimane	33.2069	6.0931	CT	180	24.9	7.56	5660	3796
54	2	21	Touggourt Ville	33.0708	6.0583	CT	170	23.4	7.45	6730	4523
55	2	23	Djamâa (Ain Zerrouk)	33.5667	6.0000	CT	180	23.3	7.38	8590	5570
56	2	24	Sidi-Khellil	33.6389	5.9708	CT	230	24.7	7.56	6160	4004

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
57	2	25	El-Meghaïer (El Alia) 1987	33.9044	5.9444	CT	271	23.9	7.59	4700	2955
58	2	26	El Meghaïer	33.9875	5.9750	CT	278	24.5	7.58	4810	3070
59	2	41	Khchem Er'rih	32.4278	5.7444	CT	120	25.7	7.36	5080	3175
60	2	43	Sidi-Belkheir	32.2986	5.5911	CT	125	24.7	7.55	6690	3753
61	2	44	El-Bekrat	31.8806	5.5292	CT	115	24.7	7.21	6830	4066
62	2	46	Istikama (Hassi Ben Abdellah)	32.0542	5.6236	CT	110	25.6	7.31	6130	3898
63	2	48	Ain-Djrad	32.1389	5.6708	CT	112	25.6	7.53	5600	3197
64	2	51	Gassi-Touil, GT3	30.5250	5.4750	CT	160	27	6.52	3170	1912
65	2	52	Gassi-Touil, HT4	30.5197	6.4667	CT	150	27.7	6.66	3650	2174
66	2	53	Gassi-Touil, GT2	30.5306	6.4817	CT	170	30.8	7.15	4030	2436
67	2	60	Gassi-Touil, M3	30.5567	6.4794	CT	165	30.1	6.99	3820	2461
68	2	61	Gassi-Touil, P	30.5633	6.4783	CT	165	29.7	7.22	3080	2018
69	2	62	Rhourde El Baguel, MP103	31.5486	6.9589	CT	100	28.5	7.04	3270	1847
70	2	63	Rhourde El Baguel, MP106	31.3769	6.9569	CT	95	28.6	7.19	3250	1828
71	2	70	Rhourde El Baguel, P1	31.4722	7.3553	CT	95	27.9	7.17	3280	1955
72	2	71	Rhourde El Baguel, MP105	31.3889	6.9519	CT	100	29.1	7.34	3970	2385
73	2	74	Hassi-Messaoud Sagra, S1	31.5042	6.3361	CT	90	29	7.63	10300	6363
74	2	75	Hassi-Messaoud, H2	31.5172	6.1883	CT	95	31.8	7.54	4520	2848
75	2	77	Djamâa Sidi-Yahia, MP5	33.5178	5.9514	CT	170	24.1	7.01	9860	6894
76	2	80	Hamraïa, HAM6	34.0933	6.3347	CT	584	33.6	7.32	4660	2813
77	2	81	Hamraïa, HAM4	34.1089	6.2258	CT	517	32.5	7.25	4770	2892

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
78	2	82	M'Guebra, GUEB	34.2564	6.0128	CT	600	31	7.49	5110	3316
79	2	84	Rhourde Nouss, RN15	28.5886	7.0847	CT		23.8	7.11	2820	1697
80	2	86	Rhourde Nouss, RN17	28.6658	6.5114	CT		28.4	7.54	3210	1971
81	2	87	Rhourde Nouss, ALCIM	29.6181	6.7139	CT		27.2	7.83	1806	910
82	2	88	El-Hamra, HRA	29.6972	6.0517	CT		29.1	7.65	1750	880
83	2	89	El-Hamra, HRA1	29.7350	6.7031	CT		29.3	7.71	1555	1034
84	2	90	Rhourde Nouss, St. Pompage	29.2250	6.4964	CT		22.5	7.71	4670	3357
85	3	1	Haz F5	33.7383	7.6031	P Q		25	6.6	10400	7500
86	3	2	Ne foret	33.8697	7.8822	P Q		24	8	7000	5280
87	3	3	A. Nasr	33.8635	7.8823	P Q		21.5	7.3	7050	5540
88	3	4	L. zouni	33.8554	7.8796	P Q		22	7.5	7155	5600
89	3	5	A. Legtari	33.9155	7.9016	P Q		24	7.8	5230	5200
90	3	6	A Amamra	34.0171	8.1658	P Q		25	7.72	9030	6800
91	3	7	K Rhouma	33.9764	8.2350	P Q		24	7.1	10000	7700
92	3	8	M Tatta	33.8469	7.8764	P Q		22.5	7.3	7950	6480
93	3	9	M zaeter	33.8388	7.7311	P Q		21	6.88	8260	6280
94	3	10	Jhim Foret	33.8738	8.1279	P Q		23	7.07	9300	7340
95	3	11	A Sekala	33.9570	8.1346	P Q		22.5	7.2	7580	6500
96	3	12	A Jhimi	33.8834	8.1375	P Q		22	7.82	9870	7580
97	3	13	H Maklouf	33.9672	8.2047	P Q		22	7.46	10550	7040
98	3	14	B Touil	33.9458	7.6600	P Q		21	6.84	10710	7640
99	3	15	B Hod	33.9209	7.6831	P Q		21	7.31	5920	4940
100	3	16	Htam	34.0047	7.6158	CT		37.4	7.5	5000	3100
101	3	17	Nefta 4b	33.8660	7.8378	CT		29.9	7.5	4000	3200

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
102	3	18	IBC 10	33.9325	7.9472	CT		29.6	7.3	4010	3100
103	3	19	Chemsa 1b	33.9594	8.0445	CT		30	7.5	3930	3100
104	3	20	Tozeur 8	33.9131	8.1309	CT		30	8.1	2800	2100
105	3	21	Ain Tor 3t	33.9873	8.2392	CT		31	7.66	2200	1800
106	3	22	Ceddada 4b	34.0119	8.3000	CT		35	7.73	4300	3190
107	3	23	Mzara	33.8989	7.6196	CT		27	7.4	3780	2800
108	3	24	Garaet Jab	33.7774	7.6471	CT		28	7.73	3000	2920
109	3	25	O Koucha	33.9868	8.2322	CT		32	7.73	2800	1890
110	3	26	Hamma 15	34.0244	8.1716	CT		32.5	7.72	2500	2340
111	3	27	IBC 1	33.9155	7.8932	CT		26	7.52	4200	3240
112	3	28	A O Ghr	33.7061	7.6537	CT		30	8	3600	2720
113	3	29	PK 14b	33.8565	7.9826	CT		29.5	8.02	2910	2160
114	3	30	D CRDA	33.9453	8.1120	CT		28	7.2	2400	1930
115	3	31	Ghardg 4b	33.8606	7.9242	CT		31	6.96	3800	3310
116	3	32	Ham. 14b	34.0104	8.1595	CT		34	7.21	4900	4290
117	3	33	Matrouh	33.3492	7.7772	CT		28.4	5.57	3490	2940
118	3	34	B Roumi	33.4165	7.8062	CT		27	7.47	3940	3010
119	3	35	Dghou 4	34.0149	8.3244	CT		37.5	8	5300	4100
120	3	36	Kriz 5	34.0114	8.2700	CT		32	7.21	6360	4100
121	3	37	Tazrarit 1	34.0210	8.3057	CT		35	7.7	8400	5880
122	3	38	Deg. Sen	33.9825	8.2439	CT		33	7.66	2600	2420
123	3	39	Nefta 2bis	33.8672	7.8605	CT		29	7.45	4100	3100
124	3	40	Manach 2b	33.9795	8.2283	CT		28.8	7.25	3060	2020
125	3	41	Rej Matoug	33.3256	8.0138	CT		26.8	6.01	2510	2316
126	3	42	Douz 2b	33.4608	9.0301	CT		25	7.55	4580	3250
127	3	43	Jemna	33.5626	9.0174	CT		24.3	6.12	1700	1470
128	3	44	Ras el Ain	33.7586	8.8819	CT		26	6.42	4620	4560
129	3	45	Zafrana	33.8575	7.8977	CT		30	7.24	3850	3240
130	3	46	Hazoua 1b	33.7381	7.6034	CT		29.7	7.9	3750	2740
131	3	47	Nefta CI1	33.8868	7.8753	CI		70	7.34	5130	3368
132	3	48	Nef CI2	33.8863	7.8767	CI		66.6	7.1	3400	2665
133	3	49	Toz CI 2	33.9147	8.1003	CI		65.5	7.1	4640	3574
134	3	50	Toz CI3	33.9147	8.0887	CI		66	7.13	4200	4200

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
135	3	51	Ham CI2	33.9902	8.1818	CI		64	8.2	5030	3377
136	3	52	Ham CI 4	34.0056	8.2052	CI		62.9	7.3	3460	2811
137	3	53	Tazra CI	34.0326	8.2911	CI		56.4	7.2	6470	4258
138	3	54	Ceda CI	34.0227	8.2744	CI		71.1	6.9	3360	2401
139	3	55	Hazoua CI	33.7481	7.6328	CI		62.7	7	2390	1766
140	3	56	Mahace CI1	34.0425	8.2162	CI		69.5	6.9	3160	2288
141	3	57	Hmm CI1b	34.0215	8.1808	CI		69.9	6.9	3470	2742
142	4	1	Ziret Louhichi	33.8103	8.7536	CT	75	24.7	7.6	4790	3476
143	4	2	Ziret Ouled Touati	33.8089	8.7694	CT	44	25.3	7.3	4830	3750
144	4	3	El Hamma Mziraa	33.8839	9.7920	CT	342	29.5	7.9	4490	3016
145	4	4	Zoumit	33.3852	9.7071	CT	355	26.7	7.4	3560	2577
146	4	5	Garet Ltaifa	33.6961	10.0985	CT	233	23.3	7.2	3480	2446
147	4	6	Oum Laabid	33.5774	8.8789	CT		20.5	8.1	3480	2741
148	4	7	Oued El Melah	33.7737	8.9296	CT		21.6	7.6	3200	2565
149	4	8	Zmerten	33.3874	10.1326	CT		27.2	7.5	1150	1120
150	4	9	Beni Zelten Sonède	33.5482	10.0996	CT	150	22.7	7.2	2610	2012
151	4	10	Matmata 5	33.6684	10.0150	CT	375	20.2	7.5	4690	3506
152	4	11	Beni Zelten 3	33.5348	10.1099	CT	50	23.7	7.2	3450	2639
153	4	12	Henchir Jehha	33.7163	9.9790	CT	410	25	7.6	3740	2712
154	4	13	Matmata Aéreport	33.7366	9.9148	CT	515	24.8	7.5	3750	2626
155	4	14	Tinia	33.4283	9.4037	CT	670	24.4	7.8	8940	6423
156	4	15	Lymaoua5	33.7035	10.0931	CT	140	27	7.6	3900	2285
157	4	16	Gourai	33.7920	9.8652	CT	550	31	7.5	4060	2648
158	4	17	Merbah Sandoug	33.4655	9.9379	CT	350	27.6	7.8	1680	1584
159	4	18	Pepiniere Tounine	33.6617	10.1356	CT	70	20	8	9650	6712
160	4	19	Zaten	33.6853	10.1022	CT	109	22	7.8	1730	1085
161	4	20	Echahba	32.7852	10.1346	CT		16.1	7.6	4810	4505
162	4	21	Sih Essraya	32.7013	9.9870	CT		22.4	8.3	4350	2450

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
163	4	22	Guelb Eddoukhane	32.8241	10.0185	CT		22.8	8.3	4830	2934
164	4	23	Bir Echahba	32.7506	10.0833	CT		21.6	7.2		996
165	4	24	Zridib	33.1661	10.0728	CT		22.7	8.1		2823
166	4	25	Bou Flija	32.9956	9.7697	CT	207	28	7.7	5600	3485
167	4	26	Bel Habel	33.4359	9.7443	CT	219	22	7.5	3290	2687
168	4	27	Bir Soltane	33.3258	9.9049	CT	325	22	7.2	3486	2373
169	4	28	Bazma Turonien	33.6742	9.0198	CT		22	7.9	6400	4746
170	4	29	Source Toujane	33.4278	10.2018	CT		20.5	8.4	970	529
171	4	30	El Mthinin	33.2866	9.9586	CT		22	7.8	3120	2266
172	4	31	Bel Khchab2	33.1358	10.1805	CT		22	7.8	2200	1483
173	4	32	Daghsen 6	32.6161	10.1921	CI	86	25.2	7	2520	1624
174	4	33	Mahbes	32.8424	9.7559	CI	620	32.9	8	4710	3334
175	4	34	El Borma Henchir	31.6039	9.3087	CI		34.8	7.5	6870	4109
176	4	35	Oued Lisseri	32.6182	10.0068	CI		20	7.5	4360	2818
177	4	36	Ksar Ghilane	32.9956	9.7697	CI	625	34	7.6	6360	4553
178	4	37	El Angoud	32.8760	10.1030	CI		20.6	8.1	5660	3928
179	4	38	El Borma A8	31.6667	9.2381	CI		33.6	7.8	4800	4166
180	4	39	Garaet Tebour5	30.6128	9.7930	CI		51	8.1	2570	1697
181	4	40	Larich	31.5320	9.6759	CI		26.8	7.4	7550	5067
182	4	41	Oued Zar	31.3772	9.9991	CI		31.5	7.4	8570	5568
183	4	42	Khchem Mariem	32.2954	9.7723	CI	405	25	7.2	6042	4031
184	4	43	Daghsen 7	32.6443	10.1446	CI	80	23.6	7.6	2650	1579
185	4	44	EL Bahair CI 9	33.8334	9.0234	CI	1268	65	7.2	3460	2351
186	4	45	Hamma CI 4	34.0268	8.1659	CI	1368	69	8.2	3510	2422
187	4	46	Guelb Fguira	32.9483	10.1491	CI	94	15	8	3100	1840
188	4	47	El Hamma Sud CI	33.8906	9.8013	CI	1188	50		5250	3559
189	4	48	Lazala (Douz CI)	33.3755	8.9928	CI	1726	51.6	7.6	5900	4114

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
190	5	1	Ali Ben Ammar Merzougui	34.1672	7.8696	PQ	7	23	7.9	6300	5180
191	5	2	Boujemaa Merzougui	34.1708	7.8956	PQ	9	23	8.1	6060	5040
192	5	3	Oudia PQ	34.2367	7.9548	PQ	106	25	7.2	5840	4600
193	5	4	Oudia PDIARI	34.2475	7.9547	PQ	72	26	7.6	6150	4600
194	5	5	O, Shili 3	34.1951	8.2049	PQ	505	30	7.8	5370	5000
195	5	6	Segdoud 3	34.2361	8.0597	PQ	870	39	7.6	5400	4820
196	5	7	Gouifla 8	34.1399	8.2870	CT	538	35	7.9	6450	6000
197	5	8	Ain Bidha Camp Maest	34.3438	7.9077	CT	Spring	22	7.5	5270	3690
198	5	9	Sce Chebika Camp-Maes	34.3300	7.9268	CT	Spring	27	7.5	4257	2980
199	5	10	Ain Morchane Eoc	34.3257	8.0854	CT	Spring	25	7.5	9360	6560
200	5	11	Draa CRDA	33.9105	8.1216	CT	56	28	7.2	2400	1930
201	5	12	IBC 14	33.9525	8.0151	CT	502	29	7.6	3960	3200
202	5	13	Hamma 9b	34.0365	8.1935	CT	90	30	7.4	7980	5900
203	5	14	Neflayet 2	33.9597	8.0496	CT	240	33	7.1	4260	3250
204	5	15	Jhim 1 b	33.8849	8.1013	CT	482	30	7.3	3050	2240
205	5	16	IBC 7	33.9355	7.9427	CT	634	29	7.2	3970	3100
206	5	17	Rgherdgaya 4	33.8632	7.9377	CT	285	31	7.1	3840	3210
207	5	18	Hotel Sarra	33.9223	8.1390	CT	50	28	6.8	4760	4000
208	5	19	Moncef 3b	33.8691	8.0560	CT	561	31	7.2	3420	2680
209	5	20	Mrah Lahouar 6	33.8617	7.9991	CT	555	31	7.3	3200	2320
210	5	21	Chemsa 1 b	33.9725	8.0976	CT	591	30	7.2	3860	3100
211	5	22	Castilia 3b	33.9409	8.1626	CT	85	30	7.4	2910	1960
212	5	23	Tozeur 9	33.9035	8.1360	CT	74	25	7.6	2750	2000
213	5	24	El Faouz	33.7722	7.6580	CT	403	30	6.8	3980	2900
214	5	25	Choucht Zerga	33.8126	7.6948	CT	385	28	7.8	3970	2900
215	5	26	El Farej 2	33.8337	7.7194	CT	362	30	7.3	4060	3200

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
216	5	27	Nefta 12	33.8731	7.8659	CT	71	29	7.1	3760	3100
217	5	28	Nefta SONEDE	33.8668	7.8930	CT	91	29	7.2	3270	2300
218	5	29	Htam	33.9762	7.6396	CT	666	37	7.2	4820	3100
219	5	30	Mzara	33.8875	7.6891	CT	323	25	7.4	3820	2500
220	5	31	Hazoua 1 ter	33.7551	7.6022	CT	473	29	7.4	3730	2700
221	5	32	Ain Ouled Ghrissi	33.6049	7.6700	CT	443	29	7.3	3720	2700
222	5	33	Degache CT	33.9566	8.1916	CT	125	23	7.7	2690	1700
223	5	34	Ain Torba 1 ter	33.9746	8.2253	CT	75	30	7.6	2380	1600
224	5	35	Koudiet Lakoua	33.9281	7.8565	CT	414	27	7.4	4010	3100
225	5	36	Hamma 21	33.9687	8.1246	CT	219	32	7.2	3900	2900
226	5	37	Hamma 14b	33.9687	8.1404	CT	98	30	7.6	3600	2600
227	5	38	Nefta CI3	33.8907	7.8216	CI	2,126	66	7.6	4400	3500
228	5	39	Hamma CI 4	33.9948	8.1614	CI	1,368	69	8.2	3510	2860
229	5	40	Ceddada CI	34.0630	8.2440	CI	2,257	74	7.9	3200	2470
230	5	41	Hazoua CI	33.8129	7.5756	CI	1,870	60	7	2390	1800
231	5	42	Mahacen CI 2	34.0355	8.2645	CI	1,370	69	6.9	3160	2300
232	5	43	Hamma CI 1bis	33.9317	8.1255	CI	1,444	73	7.5	3230	2742
233	6	1	Sif Lakdhar	33.8617	7.9392	CT		31.1	6.71	2933	2053
234	6	2	Chemsa 2bis	33.9553	8.1085	CT		30.4	6.78	3386	2370
235	6	3	Chabbat 3ter	33.9344	7.9828	CT		30.2	6.72	3386	2370
236	6	4	Moncef 3bis	33.9158	7.9932	CT		31.6	6.39	3244	2271
237	6	5	Chabbat 11bis	33.9344	7.9828	CT		30	6.65	3470	2429
238	6	6	Nelayet 3bis	33.9551	8.1301	CT		32.5	6.8	3573	2501
239	6	7	Mrah 15	33.9129	8.0554	CT		30.6	6.5	4341	3039
240	6	8	Mrah 2bis	33.8715	8.0371	CT		32.4	6.8	2724	1907
241	6	9	Mrah 1bis	33.8664	8.0133	CT		32	6.8	2840	1988
242	6	10	Nefta 4bis	33.8818	7.8633	CT		30.5	6.57	5057	3540
243	6	11	Mzara CT	33.8549	7.5772	CT		32.4	6.66	3172	2220

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
244	6	12	Cedada 8	34.0254	8.3798	CT		36.5	6.74	2639	1847
245	6	13	Cedada 10	34.0496	8.3887	CT		35.4	6.82	1870	1309
246	6	14	Ain torba	33.9872	8.2433	CT		32.8	6.83	2140	1498
247	6	15	Degache CT	34.0171	8.3099	CT		30.5	6.8	2336	1635
248	6	16	Dghoumes 4	34.0519	8.4295	CT		34.8	6.82	4531	3172
249	6	17	G.Jaballah	33.8139	7.6968	CT		32	6.7	3216	2251
250	6	18	Bir Roumi	33.6290	7.7233	CT		27.8	6.51	3286	2300
251	6	19	A.O. grissi	33.6454	7.6750	CT		30.5	6.64	3157	2210
252	6	20	Hazoua 1bis	33.6675	7.6249	CT		32.4	6.65	3160	2212
253	6	21	Htam CT	33.9745	7.6434	CT		33.4	6.69	3626	2538
254	6	22	Zaafrana	33.8599	7.9664	CT		33.7	6.76	3664	2565
255	6	23	Ghardgoy a			CT		33	6.74	3500	2450
256	6	24	Chabbat 1bis	33.9387	7.9502	CT		30	6.8	3410	2387
257	6	25	Chabbat 8	33.9433	8.0074	CT		30.6	6.75	3409	2386
258	6	26	Chabbat 13bis	33.9424	8.0360	CT		33.6	6.7	3472	2430
259	6	27	Hamma 16	34.0007	8.1489	CT		33.6	6.7	2961	2073
260	6	28	Hamma 7bis	34.0212	8.1758	CT		30.8	6.67	5565	3896
261	6	29	Hamma 5bis	34.0322	8.1864	CT		34.2	6.68	5567	3897
262	6	30	Tozeur 8	33.9100	8.1252	CT		30	6.78	2553	1787
263	6	31	Tazrarit Mtgne	34.0575	8.3685	CT		34	6.68	5554	3888
264	6	32	Tazrarit 1bis	34.0476	8.3345	CT		32.6	6.85	4286	3000
265	6	33	Dghmes Mtgne	34.0655	8.4167	CT		27.6	6.7	4774	3342
266	6	34	Dghoumes 2bis	34.0599	8.4598	CT		35.4	6.7	4816	3371
267	6	35	Kriz	34.0326	8.3457	CT		28	6.74	4725	3308
268	6	36	El Horchani	34.0343	8.2990	CT		31.6	6.75	1162	813
269	6	37	Chouchet	33.8920	8.1039	CT		30	6.78	2900	2030
270	6	38	Errached	33.8794	8.0770	CT		31.1	6.83	2800	1960
271	7	1		34.0140	8.1317	CI		69	8.2	3510	2422
272	7	2		34.0298	8.1502	CI		74	6.7	3000	2116
273	7	3		34.0478	8.4615	CI		69.5	6.9	3160	2215

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
274	7	4		34.0339	8.1780	CI			7.6	2840	2142
275	7	5		34.0339	8.1780	CI		71.5	7.3	6210	3653
276	7	6		34.0236	8.1636	CI		74	7.9	3200	2185
277	7	7		33.9230	8.1063	CI		66	7.1	4200	2565
278	7	8		33.8204	7.5673	CI		73	6.8	2930	1855
279	7	9		33.7384	7.6034	CI		60	7	2430	10908
280	7	10		33.8773	7.8841	CI		70	7.3	5130	3271
281	7	11		33.8407	9.3052	CI		55.6	7.7	3620	2592
282	7	12		33.4355	9.0100	CI		51.6	7.6	5900	4114
283	7	13		33.7898	9.0872	CI		69.7	8	3250	2090
284	7	14		33.7796	8.8706	CI		52	7.6	4940	3280
285	7	15		33.8281	8.6473	CI		71	7.1	4640	2097
286	7	16		33.8406	8.7786	CI		68	7.4	2830	1761
287	7	17		33.8387	9.0061	CI		72.5	7.5	3250	2184
288	7	18		34.0049	9.6160	CI		67.6	7	3040	2093
289	7	19		33.9371	9.6845	CI		52		3670	2394
290	7	20		33.9217	9.6563	CI				3700	2564
291	7	21		33.8988	9.7882	CI		50		5250	3559
292	7	22		33.9426	9.6154	CI		32	7.2	7260	4309
293	7	23		32.9609	10.1338	CI		20	8	3100	1840
294	7	24		32.6352	10.1611	CI		23.6	7.6	2650	1579
295	7	25		32.0000	10.4217	CI		27	7.5	2380	1552
296	7	26		32.0005	10.6741	CI		26.4	7.5	2210	1633
297	7	27		33.3864	10.2050	CI		26.2	8.1	3300	2160
298	7	28		32.5958	10.2061	CI		25.2	7	2520	1624
299	7	29		32.2603	10.2548	CI		26.6	7.4	1820	1234
300	7	30		32.2487	10.3325	CI		26	7.9	2850	1792
301	7	31		32.2203	10.0500	CI		26.4	6.9	3810	2543
302	7	32		32.8600	10.0100	CI		20.6	8.1	5660	3928
303	7	33		32.1597	10.4075	CI			7.6	8770	6072
304	7	34		33.3413	10.2868	CI			7.9	2380	1628
305	7	35		32.2719	10.3872	CI			7.8	1990	1316
306	7	36		31.5376	9.5742	CI		26.8	7.4	7550	5068
307	7	37		31.6908	9.2192	CI		33.6	7.8	4800	4166
308	7	38		31.6662	9.2575	CI		34.8	7.5	6870	4110

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
309	7	39		30.9750	9.9757	CI			7.2	1280	2712
310	7	40		31.1217	9.7645	CI		30.3	7.5	4770	3402
311	7	41		30.5561	9.8249	CI		51	8.1	2570	1697
312	7	42		31.4451	9.9752	CI		31.5	7.4	8570	5568
313	7	43		30.9532	9.4433	CI				7900	5157
314	7	44		33.1020	9.9611	CT		22.7	8.09		2823
315	7	45		33.3642	9.9900	CT		27.2	7.45		1120
316	7	46		33.5910	9.9082	CT		27.6	7.75	1200	1584
317	7	47		33.6750	9.6163	CT		24	6.7	3890	2452
318	7	48		32.0155	10.7416	CT		21.8	8.1	3680	1809
319	7	49		33.9067	9.7604	CT		30.5	7.5	4320	2820
320	7	50		33.9067	9.7769	CT		32.5	7,170	7170	3919
321	7	51		33.9149	9.8514	CT		41.6	7.7	4250	2906
322	7	52		33.9076	9.8705	CT		34	7.7	5180	4057
323	7	53		33.9126	9.8601	CT		41	7.9	4700	3188
324	7	54		33.9132	9.7591	CT		44	7.4	4600	2350
325	7	55		33.9036	9.8431	CT		45.6	7.7	4460	3400
326	7	56		33.8976	9.8003	CT		46.2	7.5	4180	3145
327	8	1	Nefta CI1	33.8868	7.8753	CI		70	7.34	5130	3368
328	8	2	Nefta CI2	33.8863	7.8767	CI		72	7.17	4700	2717
329	8	3	Tozeur CI2	33.9147	8.1003	CI		68	7.33	5880	3334
330	8	4	Tozeur CI3	33.9147	8.0887	CI		66	7.13	4200	2519
331	8	5	El Hamma CI2	33.9902	8.1818	CI		64	8.2	5030	3377
332	8	6	El Hamma CI4	34.0056	8.2052	CI		73	7.57	4753	3191
333	8	7	Ceddada CI	34.0227	8.2744	CI		68	7.11	3765	2510
334	8	8	Chorfa CI 4	33.7882	8.8324	CI		70	7.18	4440	2180
335	8	9	Zouia CI 5	33.7904	8.8041	CI		71	7.24	4360	2271
336	8	10	Mansoura CI 3	33.7266	8.9432	CI		52	7.57	4940	3346
337	8	11	Mansoura CI 13	33.7329	8.9872	CI		65	7.74	3680	2178
338	8	12	Kebili CI 10	33.7009	9.0071	CI		66	7.55	3930	2311
339	8	13	Kebili CI 16	33.6824	8.7694	CI		70	7.2	3130	2138

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
340	8	14	Touargha CI 2	33.7873	9.2591	CI		46	7.2	3130	2244
341	8	15	El Bhaier CI 9	33.7860	9.0849	CI		65	7.17	3460	2421
342	8	16	Limlagues CI 8	33.7792	8.7523	CI		67	7.3	3340	2317
343	8	17	Debabcha CI 14	33.8021	8.7362	CI		71	7.07	4640	2167
344	8	18	Souk El Ahad 17	33.8067	8.8631	CI		68	7.35	2830	1827
345	8	19	Douz CI 12	33.4471	9.0368	CI		53	7.7	5580	3650
346	8	20	Djemna CI 11	33.5542	9.0170	CI		59	8.03	4040	2791
347	8	21	Saidane	33.7536	9.2969	CI		56	7.24	3750	2975
348	8	22	CF2	33.9016	9.5772	CI		65	7.2	3762	2508
349	9	1	M. Zaeter	33.8658	7.8453	PQ	15				6111
350	9	2	M. Tatta	33.8653	7.8858	PQ	15				5056
351	9	3	Nefta forêt	33.8664	7.9031	PQ	15				4840
352	9	4	Jhim forêt	33.9000	8.1200	PQ	25				6981
353	9	5	A. Jhimi	33.9014	8.1233	PQ	25				6292
354	9	6	A. Sekala	33.9325	8.1531	PQ	30				5504
355	9	7	H. Maklouf	33.0889	7.8931	PQ	10				6409
356	9	8	K.Rhouma	33.9683	8.2025	PQ	15				6869
357	9	9	Htam	33.9775	7.6456	CT	805				2693
358	9	10	Mzara	33.8283	7.6169	CT	375				2563
359	9	11	Gara. Jaballah	33.8103	7.6936	CT	450				2559
360	9	12	A. O.Ghrissi	33.6811	7.6881	CT	550				2317
361	9	13	Bir Roumi	33.4686	7.7172	CT	348				2590
362	9	14	Matrouha 2	33.3708	8.6858	CT	302				2559
363	9	15	R. Matoug 2	33.3019	8.0250	CT	225				2559
364	9	16	Ghardgay a 4b	33.8614	7.9678	CT	423				3141
365	9	17	PK 14b	33.8725	8.0433	CT	630				2064
366	9	18	Drâa CRDA	34.0042	8.2014	CT	104				1800

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
367	9	19	Hamma 14b	33.9942	8.1617	CT	133				2865
368	9	20	Tozeur 8	33.9153	8.1358	CT	415				1771
369	9	21	O. Koucha 2b	33.9592	8.1900	CT	354				1804
370	9	22	Deghoumes 4	34.0242	8.3239	CT	623				4033
371	9	23	Sabria Mol	32.7528	8.5333	CT	333				1000
372	9	24	Faouar 4	32.7500	8.6750	CT	195				1366
373	9	25	Fatnassa 2	33.5589	8.7500	CT	185				3016
374	9	26	Zarcine 1	33.0861	8.8194	CT	200				1609
375	9	27	Ras el Ain	33.3333	8.8000	CT	214				4032
376	9	28	Negga 6	33.4861	8.8306	CT	251				1726
377	9	29	Zafrane 3b	32.9008	8.7500	CT	122				1061
378	9	30	Jemna 1bis	32.9283	8.9169	CT	150				1146
379	9	31	Douz 2b	32.8500	9.0364	CT	123				3017
380	10	1		33.9867	8.2292	PQ		21.5	6.5		4400
381	10	2		33.8845	8.1147	PQ		14.8	6.6		8300
382	10	3		33.9757	8.0388	PQ		16.5	6.7		6500
383	10	4		34.0272	8.1800	PQ		27.6	6.6		6300
384	10	5		33.7227	7.6037	PQ		21.8	6.5		3100
385	10	6		33.8848	8.1442	PQ		24.5	6.6		9300
386	10	7		33.8584	7.8589	PQ		20	6.5		7100
387	10	8		33.8558	7.8795	PQ		21.4	7.6		6400
388	10	9		33.8585	7.8462	PQ		23	7.7		7200
389	10	10		33.8935	8.1675	PQ		22	7.1		7100
390	10	11		33.9882	8.2551	PQ		22.3	7.8		7400
391	10	12		33.9406	8.1734	PQ		20	6.8		8700
392	10	13		33.8626	7.7335	PQ		21.7	6.5		6000
393	10	14		33.8586	7.8295	PQ		22.2	6.7		5600

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
394	10	15		33.9801	8.1156	PQ		21.5	7		5800
395	10	16		34.0189	8.3039	PQ		24	6.5		7200
396	10	17		33.9697	8.0964	PQ		22	6.7		6500
397	10	18		33.7074	7.6575	PQ		22	7.2		5500
398	10	19		33.8625	7.9030	PQ		22.4	6.8		4800
399	10	20		33.8123	7.6996	PQ		23.1	6.9		6900
400	10	21		33.9952	8.1478	PQ		22.7	6.5		5200
401	10	22		33.8619	7.9297	PQ		22	6.5		8000
402	10	23		33.8618	7.9162	PQ		23	6.7		7300
403	11	1	Sondous	34.3544	7.8560	PQ	143-193				2550
404	11	2	Hajra Beida	34.3095	7.9025	PQ	110-178				3000
405	11	3	Oudia PQ	34.2462	8.0166	PQ	72-135				4600
406	11	4	Bir Lahnak	34.2000	8.1667	PQ	146-203				8560
407	11	5	Krichet Naam 4	34.3131	8.2861	PQ	191-280				3100
408	11	6	M. Ben Amor	34.1879	7.6619	PQ	<50				9900
409	11	7	Lazhar B. Taher	34.1732	7.7063	PQ	<50				8330
410	11	8	Boujema Marzougui	34.1808	7.7542	PQ	<50				4970
411	11	9	Ali Marzougui	34.1808	7.7830	PQ	<50				5320
412	11	10	Terzi B. Gargah	34.2056	7.7710	PQ	<50				6550
413	11	11	Khlifa Chraiti	34.2943	8.0949	PQ	<50				6530
414	11	12	Ali Ferjaoui	34.2874	8.1476	PQ	<50				4250
415	11	13	Abdallah Hechmi	34.2765	8.1317	PQ	<50				11400
416	11	14	Oued Hachana	34.3043	8.2319	PQ	<50				3960
417	11	15	Ben Gacha	34.2036	7.6199	CT	1081-1159				3700
418	11	16	Dafria 1	34.2067	7.7962	CT	1174-1306				4200

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
419	11	17	Dafria 2	34.2087	7.8343	CT	1064-1220				3620
420	11	18	Dafria 3	34.1984	7.8819	CT	1052-1203				3640
421	11	19	Sagdoud 1	34.3077	8.1100	CT	931-1015				4950
422	11	20	Sagdoud 2	34.3038	8.1363	CT	946-1042				5600
423	11	21	Sagdoud 3	34.3077	8.1684	CT	846-1076				4500
424	11	22	Oudia CT1	34.1948	8.2043	CT	672-760				3400
425	11	23	Chakmou	34.0983	8.2057	CT	1057-1175				6220
426	11	24	Thalja	34.3235	8.3198	CT	345-429				4100
427	11	25	Oued Shili 4	34.2630	8.2915	CT	660-799				4650
428	11	26	Oued Shili 3	34.2525	8.2817	CT	565-658				5170
429	11	27	Gouifla 8	34.1347	8.3110	CT	538-603				6500
430	11	28	Gouifla 7	34.1386	8.2909	CT	565-639				7050
431	12	1	Bazma	33.6596	9.0136	CT		24.3			2077
432	12	2	Bechelli 4	33.6160	8.9190	CT		26.2			1488
433	12	3	Blidette 6	33.5750	8.8459	CT		27.6			1698
434	12	4	Bou Abdallah 2	33.7783	8.8451	CT					3954
435	12	5	Chott Salhia 1	33.5974	9.0039	CT					1371
436	12	6	Dar Kouskouss i 1 bisc	33.7059	8.9778	CT					4605
437	12	7	Douz 2 bis	33.4695	8.9452	CT		22			4277
438	12	8	Douz East	33.4470	9.0142	CT		24			4557
439	12	9	El Gléa 3	33.7730	8.8572	CT		27			3805
440	12	10	El Hsay 5 bis	33.4695	8.9452	CT		23			6490
441	12	11	Fatnassa 2	33.7952	8.7420	CT					3188
442	12	12	Ghidma 1	33.4695	8.9452	CT		24			1428
443	12	13	Guettaya 4 bis	33.6818	8.8881	CT					1790
444	12	14	Kelwamen	33.5895	8.9098	CT		24.2			1839
445	12	15	Kelwamen Sonede	33.5884	8.8994	CT					1703

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
446	12	16	Klebia 2	33.5028	8.8740	CT		24.8			1712
447	12	17	Ksar Tabeul 2	33.7010	8.9764	CT		26.8			3510
448	12	18	Mannsoura 2 bis	33.7343	8.9365	CT					2217
449	12	19	Messaid 5	33.6205	8.9648	CT					1590
450	12	20	Negga 4 bis	33.7397	8.8277	CT		28.3			1884
451	12	21	Nouiel	33.5028	8.8739	CT		28			1516
452	12	22	Oued Zira 3	33.7615	8.8935	CT		26.7			3896
453	12	23	PZ Dergine el Ameurd	33.4886	8.7139	CT					1248
454	12	24	PZ Graadd	33.5125	8.9968	CT					642
455	12	25	Rahmat Forest	33.6262	9.0021	CT					1590
456	12	26	Rahmat Sonede	33.6336	9.0005	CT		24.8			1880
457	12	27	Scast 7	33.6059	9.0218	CT		24.3			2956
458	12	28	Taouergha	33.4695	8.9452	CT		29			3676
459	12	29	Telmine 3 bis	33.7172	8.9156	CT		26			2331
460	12	30	Tifout	33.7058	8.9091	CT		29			1705
461	12	42	Jemna CI-11	33.5545	9.0132	CI		59			2725
462	12	43	Kebili CI-10	33.7008	8.9824	CI					7514
463	12	44	Tinia CI 15	33.3911	9.2964	CI		64			6991
464	13	1	Adr 01	27.7603	-0.2653	CI		14.5	8.1	1455	959
465	13	2	Adr 02	27.7472	-0.2306	CI		24.4	7.4	2940	2077
466	13	3	Adr 03	27.7028	-0.3369	CI		26.4	7.2	2960	1939
467	13	4	Adr 04	27.3861	-0.1631	CI		30.6	7.1	2330	1543
468	13	5	Adr 05	27.3761	-0.1786	CI		28	7.2	2240	1513
469	13	6	Adr 06	27.2678	-0.0997	CI		26.7	7.2	2120	1474
470	13	7	Adr 07	27.1894	-0.1667	CI		20.1	8.1	1902	1292
471	13	8	Adr 08	27.1625	-0.1261	CI		26.6	7.4	2070	1403
472	13	9	Adr 09	27.1042	-0.0675	CI		27.4	7.3	2160	1493
473	13	10	Adr 10	27.5453	-0.2592	CI		26.5	7.3	2520	1707
474	13	11	Adr 11	26.9731	-0.0106	CI		25.8	7.6	2600	1700
475	13	12	Adr12	26.8181	0.0103	CI		22.3	7.5	15270	10551

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
476	13	13	Adr 13	26.9947	-0.0147	CI		26.5	7.3	2850	1825
477	13	14	Adr 14	28.0206	-0.4483	CI		24.5	7.8	3420	2214
478	13	15	Adr 15	28.0092	-0.4008	CI		22.8	7.6	3140	2025
479	13	16	Adr 16	28.1550	-0.1322	CI		24.6	7.6	1522	1030
480	13	17	Adr 17	28.4522	-0.0483	CI		25.6	7.5	1080	677
481	13	18	Adr 18	28.5933	0.0442	CI		26.8	7.5	1241	825
482	13	19	Adr 19	28.4158	-0.2522	CI		24.8	7.7	2660	1280
483	13	20	Adr 20	28.3056	-0.2386	CI		26.4	7.6	1984	1158
484	13	21	Aou 01	27.0586	1.0303	CI		27.8	7.3	2140	1417
485	13	22	Aou 02	26.9828	1.0969	CI		26.5	7.4	3260	2127
486	13	23	Aou 03	26.9436	1.4922	CI		28.8	7.5	1758	1151
487	13	24	Aou 04	27.0264	1.6172	CI		29	7.5	1940	1259
488	13	25	Aou 05	26.7272	1.3775	CI		28.7	7.6	2590	1807
489	13	26	Elm 01	29.9544	2.6542	CI		28	7.8	848	476
490	13	27	Elm 02	30.5944	2.9003	CI		27.3	7.8	339	198
491	13	28	Inb 01	27.8861	1.1703	CI			7.6	722	443
492	13	29	Krz 01	29.4528	-1.4081	CI		25.4	7.7	896	884
493	13	30	Krz 02	29.4922	-1.4967	CI		25.3	7.7	645	362
494	13	31	Reg 01	26.7836	0.0961	CI		25.3	7.5	2550	1674
495	13	32	Reg 02	26.6911	0.2872	CI		27.1	7.4	5620	4082
496	13	33	Reg 03	26.7144	0.2186	CI		29.7	7.3	3590	2427
497	13	34	Tim 01	28.7342	0.3314	CI		25.4	7.7	1277	808
498	13	35	Tim 02	29.0372	-0.2478	CI		24.4	7.7	3170	1689
499	13	36	Tim 03	29.0256	-0.2661	CI		18.9	8.1	2870	1769
500	13	37	Tim 04	29.4256	-0.0742	CI		25	7.8	1439	858
501	13	38	Tim 05	29.2447	-0.2603	CI		26.8	7.4	2220	1551
502	13	39	Tim 06	29.7350	0.7406	CI		21.7	7.5	1189	742
503	13	40	Tim 07	29.7858	0.6906	CI		23.5	7.6	666	597
504	13	41	Tim 08	29.7650	0.6708	CI		24	7.3	3990	2682
505	13	42	Tim 09	29.7372	0.6611	CI		23.6	7.4	2410	1472
506	13	43	Tim 10	29.4189	0.2428	CI		23.6	7.2	5690	4058
507	13	44	Tim 11	29.4206	0.2397	CI		19.9	7.9	1561	1466
508	13	45	Tim 12	29.3914	0.3592	CI		26.4	7.6	1709	1063
509	13	46	Tim 13	29.3047	0.5300	CI		24.8	7.5	1481	950
510	13	47	Tim 14	29.3583	-0.4483	CI		21.9	7.7	1213	683

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
511	13	48	Tim 15	29.3458	-0.4750	CI		24.3	7.5	2630	1641
512	13	49	Tim 16	29.1417	-0.7522	CI		23.7	7.7	2900	1960
513	13	50	Tim 17	29.2919	0.6942	CI		17.6	8.1	974	612
514	13	51	Tim 18	29.5125	1.5592	CI		26.4	7.6	2510	1705
515	13	52	Tim 19	29.5208	1.5631	CI		26.1	7.7	1291	784
516	13	53	Tim 20	29.2789	1.0911	CI		16.3	8	2410	1587
517	13	54	Tim 21	29.2644	0.2314	CI		24.7	7.7	3490	2628
518	13	55	GHA 01	32.6119	3.7211	CI		32.3	7.3	2040	1240
519	13	56	GHA 02	32.8397	3.9033	CI		32.2	7.2	1673	961
520	13	57	GHA 03	32.8294	3.7725	CI		32.5	7.5	1363	767
521	13	58	GHA 04	32.8347	3.7617	CI		32	7.4	1447	806
522	13	59	LAG 01	33.6483	2.4497	CI		19.3	7.5	1445	957
523	13	60	LAG 02	33.5697	2.1067	CI		23.3	7.4	565	320
524	13	61	LAG 03	33.5147	2.0689	CI		25.1	-	2550	1689
525	13	62	LAG 04	33.5322	2.1458	CI		24.9	6.9	2946	2809
526	13	63	LAG 05	33.6150	2.6206	CI		23.6	7.2	862	576
527	13	64	LAG 06	33.8253	2.9081	CI		24.6	7.3	1970	1363
528	13	65	LAG 07	33.8300	2.9861	CI		22.3	7.1	1690	1078
529	13	66	LAG 08	33.8567	2.9772	CI		23.2	7.3	937	599
530	13	67	LAG 09	33.8581	2.9964	CI		23.7	7.3	1578	964
531	13	68	LAG 10	33.9133	2.4861	CI		20.8	7.1	1869	1302
532	13	69	LAG 11	33.8556	2.8911	CI		21.3	7.2	5120	3517
533	13	70	LAG 12	33.4314	1.9967	CI		19.6	7.3	3600	2227
534	13	71	LAG 13	33.4317	1.9950	CI		19.4	7.4	3570	2066
535	13	72	LAG 14	33.8556	2.7114	CI		20.1	7.2	513	219
536	13	73	LAG 15	33.8478	2.8181	CI		21.2	7.1	2170	1452
537	13	74	LAG 16	33.8469	2.8161	CI		21.2	7.2	2870	2065
538	13	75	LAG 17	33.7933	3.1086	CI		24.1	7.3	2900	2141
539	13	76	LAG 18	33.7961	2.8514	CI		19.1	6.9	2850	2096
540	13	77	LAG 19	33.4103	3.5497	CI		30.3	6.9	2090	1277
541	13	78	LAG 20	33.4197	3.5514	CI		19.6	7.2	803	453
542	13	79	LAG 21	32.8639	3.4494	CI		33.9	7.4	2220	1161
543	13	80	LAG 22	32.8439	3.3853	CI		33.9	7.3	2070	1146
544	13	81	LAG 23	32.8167	3.1678	CI		24.6	7.3	1321	782
545	13	82	LAG 24	33.1389	3.2558	CI		26.3	7.2	1009	562

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
546	13	83	S1	30.1167	-2.1694	CI		26.2	7.3	587	249
547	13	84	S3	30.1044	-2.1533	CI		25.6	7.4	642	276
548	13	85	R1	30.1125	-2.1664	CI		23.5	7.7	866	437
549	13	86	F'10	30.2628	-2.3672	CI		20.4	7	812	370
550	13	87	Z3	30.2111	-2.3108	CI		21.2	7.8	2050	954
551	13	88	Z6	30.1906	-2.2436	CI		18.6	-	4110	1684
552	13	89	SD	30.1436	-2.2197	CI		21.2	-	710	258
553	13	90	SG4	30.1158	-2.2183	CI		27.3	-	686	271
554	13	91	SG6	30.4653	-2.2878	CI		24.8	7.3	674	280
555	13	92	IG3	30.4400	-2.2828	CI		26	7.6	464	185
556	13	93	IG5	30.3861	-2.2817	CI		24.5	7.3	476	199
557	13	94	TZ3	30.3306	-2.2881	CI		26.4	7	488	174
558	13	95	MZ2	30.3658	-2.2714	CI		21.6	7.2	3950	2111
559	13	96	MZ3	30.3292	-2.2656	CI		25.9	7.7	481	152
560	13	97	MZS4	29.9217	-1.9633	CI		25.9	7.2	505	164
561	13	98	B1	29.9033	-1.9017	CI		25.5	7.3	1251	587
562	13	99	TM1	29.8472	-1.8092	CI		26.5	7.4	1102	483
563	13	100	M1	29.8489	-1.7758	CI		26.4	7.4	781	295
564	13	101	AN1	29.8156	-1.7522	CI		26.5	8.4	1143	396
565	13	102	A1	29.7836	-1.7464	CI		25.4	7	1641	371
566	13	103	KH12	29.6611	-1.6658	CI		22.2	7.3	910	388
567	13	104	KH10	29.5733	-1.6131	CI		25	7.2	993	440
568	13	105	KH9	29.4778	-1.5008	CI		25.7	7	1382	705
569	13	106	KH7	29.4756	-1.4792	CI		26.8	7.1	925	417
570	13	107	KH4	29.3231	-1.1306	CI		26.6	7.2	1597	485
571	13	108	KH3	29.3050	-1.0958	CI		26.9	7.5	1300	797
572	13	109	KH1	29.2569	-1.0672	CI		26.9	7.2	2100	1158
573	13	110	RF1	29.2653	-1.0383	CI		26.8	7.4	1372	676
574	13	111	KS1	29.1311	0.9839	CI		26.5	7.4	1695	827
575	14	1/1	1	33.7383	7.6031	PQ	4-50		7.3	6330	5610
576	14	2/1	2	33.7383	7.6031	PQ	4-50		7.4	7200	6030
577	14	3/1	3	33.7383	7.6031	PQ	4-50		6.5	10800	8650
578	14	4/2	4	33.8764	7.8836	PQ	4-50		7.9	6530	5270

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
579	14	5/2	5	33.8764	7.8836	PQ	4-50		7.2	6620	5530
580	14	6/2	6	33.8764	7.8836	PQ	4-50		7.4	8260	6490
581	14	7/2	7	33.8764	7.8836	PQ	4-50		7.2	6600	5520
582	14	8/2	8	33.8764	7.8836	PQ	4-50		7.4	6810	5570
583	14	9/3	9	33.8606	8.0189	PQ	4-50		7.4	8840	6870
584	14	10/8	10	33.9367	7.5175	PQ	4-50		7.7	6220	5190
585	14	11/9	11	34.0953	8.2056	PQ	4-50		8	10400	7970
586	14	12/9	12	34.0953	8.2056	PQ	4-50		7	9450	7310
587	14	13/5	13	33.9481	8.1761	PQ	4-50		7.6	8690	6810
588	14	14/5	14	33.9481	8.1761	PQ	4-50		8.1	6580	5370
589	14	15/5	15	33.9481	8.1761	PQ	4-50		7.3	10450	7030
590	14	16/9	16	34.0953	8.2056	PQ	4-50		7.6	9560	7950
591	14	17/9	17	34.0953	8.2056	PQ	4-50		7.1	8000	6430
592	14	18/4	18	33.9239	8.1311	PQ	4-50		7.1	7480	6490
593	14	19/9	19	34.0953	8.2056	PQ	4-50		7	9450	7310
594	14	20/4	20	33.9239	8.1311	PQ	4-50		7.7	9770	7570
595	14	21/2	21	33.8764	7.8836	PQ	4-50		7.5	8770	7170
596	14	22/2	22	33.8764	7.8836	PQ	4-50		7.2	7850	6470
597	14	23/2	23	33.8764	7.8836	PQ	4-50		7.2	8370	7070
598	14	24/4	24	33.9239	8.1311	PQ	4-50		7	9200	7330
599	14	25/2	25	33.8764	7.8836	PQ	4-50		7.3	9670	7370
600	14	26/1	26	33.7383	7.6031	PQ	4-50		7.2	5820	4930
601	14	27/1	27	33.7383	7.6031	PQ	4-50		6.5	10800	8650
602	14	28/2	28	33.8764	7.8836	PQ	4-50		6.7	10610	7630
603	14	29/2	29	33.8764	7.8836	PQ	4-50		6.8	8160	6270

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(µS/cm)	(mg/l)
604	14	30/ 6 7	30	33.9558	8.3964	P Q	4-50			9900	7690
605	14	31/ 12	31	34.1972	7.8186	P Q	4-50		7.8	6230	5310
606	14	32/ 12	32	34.1972	7.8186	P Q	4-50		7.8	11200	10090
607	14	33/ 12	33	34.1972	7.8186	P Q	4-50		8.2	7480	6240
608	14	34/ 12	34	34.1972	7.8186	P Q	4-50		7.8	8550	11390
609	14	35/ 12	35	34.1972	7.8186	P Q	4-50		7.8	11500	10090
610	14	36/ 11	36	34.2600	7.9333	P Q	4-50		7.4	3610	2990
611	14	37/ 10	37	34.2406	8.0819	P Q	4-50		7.9	2900	2540
612	14	38/ 11	38	34.2600	7.9333	P Q	4-50		8	4740	3890
613	14	39/ 7	39	34.0097	8.5175	P Q	4-50		7.4	9750	7670
614	14	40/ 12	40	34.1972	7.8186	P Q	4-50		7.7	2220	2040
615	14	41/ 12	41	34.1972	7.8186	P Q	4-50		7.5	9280	7890
616	14	42/ 12	42	34.1972	7.8186	P Q	4-50		8	11100	9190
617	14	43/ 12	43	34.1972	7.8186	P Q	4-50		7.8	19800	15230
618	14	44/ 12	44	34.1972	7.8186	P Q	4-50		7.8	32500	26730
619	14	45/ 12	45	34.1972	7.8186	P Q	4-50		7.6	7650	6630
620	14	46/ 12	46	34.1972	7.8186	P Q	4-50		7.8	6230	5310
621	14	47/ 12	47	34.1972	7.8186	P Q	4-50		7.7	6730	5790
622	14	48/ 12	48	34.1972	7.8186	P Q	4-50		7.6	10000	8050
623	14	49/ 12	49	34.1972	7.8186	P Q	4-50		7.8	12300	10410
624	14	50/ 12	50	34.1972	7.8186	P Q	4-50		7.2	12700	10150
625	14	51/ 12	51	34.1972	7.8186	P Q	4-50		7.8	6230	4960
626	14	52/ 12	52	34.1972	7.8186	P Q	4-50		7.8	10400	7550
627	14	53/ 12	53	34.1972	7.8186	P Q	4-50		7.9	19800	15670
628	14	54/ 12	54	34.1972	7.8186	P Q	4-50		7.9	19300	16690

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
629	14	55/ 12	55	34.1972	7.8186	P Q	4-50		7.8	8570	7270
630	14	56/ 12	56	34.1972	7.8186	P Q	4-50		7.6	9520	8290
631	14	57/ 12	57	34.1972	7.8186	P Q	4-50		7.7	18900	14310
632	14	58/ 12	58	34.1972	7.8186	P Q	4-50		7.6	15200	13070
633	14	59/ 12	59	34.1972	7.8186	P Q	4-50		7.9	13000	11570
634	14	60/ 12	60	34.1972	7.8186	P Q	4-50		7.7	12000	8530
635	14	61/ 12	61	34.1972	7.8186	P Q	4-50		7.8	11500	10110
636	14	62/ 12	62	34.1972	7.8186	P Q	4-50		7.8	11200	10090
637	14	63/ 12	63	34.1972	7.8186	P Q	4-50		7.6	940	9950
638	14	64/ 12	64	34.1972	7.8186	P Q	4-50		8.6	8670	7570
639	14	65/ 12	65	34.1972	7.8186	P Q	4-50		7.8	12100	10150
640	14	66/ 12	66	34.1972	7.8186	P Q	4-50		7.9	10800	8840
641	14	67/ 12	67	34.1972	7.8186	P Q	4-50		7.7	10300	8730
642	14	68/ 12	68	34.1972	7.8186	P Q	4-50		7.8	9850	6630
643	14	69/ 12	69	34.1972	7.8186	P Q	4-50		7.7	10300	8670
644	14	70/ 12	70	34.1972	7.8186	P Q	4-50		8.2	7470	6240
645	14	71/ 12	71	34.1972	7.8186	P Q	4-50		7.8	11600	10040
646	14	72/ 12	72	34.1972	7.8186	P Q	4-50		7.8	13300	12270
647	14	73/ 12	73	34.1972	7.8186	P Q	4-50		7.7	9700	9090
648	14	74/ 12	74	34.1972	7.8186	P Q	4-50		7.7	8030	7170
649	14	75/ 12	75	34.1972	7.8186	P Q	4-50		7.7	9700	9030
650	14	76/ 11	76	34.2600	7.9333	P Q	4-50		7.7	3430	3440
651	14	77/ 11	77	34.2600	7.9333	P Q	4-50		7.8	5760	4250
652	14	78/ 11	78	34.2600	7.9333	P Q	4-50		7.6	3300	3390
653	14	79/ 10	79	34.2406	8.0819	P Q	4-50		7.8	8550	11390

Master #	Study Ref. #	Well Ref. #	Locality	Lat.	Long.	Aquifer	Depth	T	pH	SEC	TDS
				D.D.	D.D.		(m)	(°C)		(μS/cm)	(mg/l)
654	14	80/ 10	80	34.2406	8.0819	P Q	4-50		7.7	5630	4970
655	14	81/ 10	81	34.2406	8.0819	P Q	4-50		7.1	7340	6610
656	14	82/ 10	82	34.2406	8.0819	P Q	4-50		7.7	26400	22890
657	14	83/ 10	83	34.2406	8.0819	P Q	4-50		7.7	4390	3850
658	14	84/ 10	84	34.2406	8.0819	P Q	4-50		7.6	5740	4870
659	14	85/ 10	85	34.2406	8.0819	P Q	4-50		7.7	7020	6110

Table 4 Major ion data and Charge Balance Error of the NWSAS

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
1	1	1	242	9	180	78	137	580	379	2.23
2	1	2	198	10	163	75	155	483	334	2.55
3	1	3	229	8	160	70	139	593	320	0.55
4	1	5	73	9	185	65	168	513	159	0.17
5	1	6	155	8	361	98	210	1090	234	0.45
6	1	7	184	17	161	68	175	453	318	1.82
7	1	8	137	13	97	41	184	294	189	0.12
8	1	9	155	18	133	61	198	384	256	1.04
9	1	10	232	19	164	69	166	476	411	0.44
10	1	12	204	29	189	66	151	722	395	-7.88
11	1	14	205	34	210	73	167	662	448	-5.19
12	1	16	240	34	215	79	153	725	510	-5.70
13	1	17	268	43	227	92	165	663	502	1.57
14	1	18	263	40	214	95	174	666	488	0.75
15	1	20	315	39	270	100	154	764	627	0.40
16	1	22	222	38	191	85	174	579	419	0.77
17	1	37	346	47	280	105	139	674	560	9.51
18	1	38	629	37	185	37	108	1000	438	7.45

Master #	Ref. #	Well Ref. #	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
19	1	39	294	50	275	78	152	700	480	5.56
20	1	40	281	40	246	91	153	677	450	5.97
21	1	42	276	32	181	78	173	554	438	2.81
22	1	45	271	32	188	77	168	517	435	4.68
23	1	47	257	30	161	70	173	463	430	2.24
24	1	49	315	12	163	64	152	430	482	4.49
25	1	50	252	11	133	55	166	425	360	1.53
26	1	78	218	38	209	86	101	570	390	6.56
27	1	79	200	40	229	86	110	600	390	5.48
28	1	101	529	70	412	67	140	1510	600	0.17
29	1	102	374	63	371	43	144	1380	320	-0.20
30	1	103	3500	80	889	279	104	1840	5960	3.13
31	1	104	601	49	347	39	134	1620	520	-2.75
32	1	105	327	60	390	46	-110	1320	356	4.42
33	1	106	652	46	304	30	256	1710	360	-2.86
34	1	107	513	55	287	31	134	1450	696	-12.36*
35	1	108	925	110	196	33	33	454	1600	0.37
36	1	109	336	90	340	38	207	1030	442	-0.41
37	1	110	330	47	266	74	134	691	620	1.24
38	1	111	335	48	284	79	134	716	656	1.18
39	1	112	562	39	408	88	122	1260	850	0.77
40	1	113	345	43	257	68	140	708	600	0.79
41	1	114	387	42	263	67	134	784	616	0.93
42	1	115	396	41	185	65	122	703	610	-1.49
43	1	116	341	43	269	72	146	740	620	-0.04
44	1	117	363	47	306	74	128	808	676	0.48
45	1	118	365	44	285	71	110	790	634	1.21
46	1	119	306	45	271	72	128	734	592	-0.23
47	1	120	281	42	201	61	110	645	464	0.10
48	1	121	488	52	277	30	43	1440	700	-12.96*
49	1	122	341	47	271	79	140	710	652	0.79
50	2	11	365	14	394	145	126	1550	618	-3.96
51	2	13	396	29	381	177	121	1510	824	-4.73

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
52	2	15	450	28	404	171	125	1380	897	-1.41
53	2	19	660	26	430	135	122	1400	1072	0.45
54	2	21	851	41	467	186	124	1500	1404	2.53
55	2	23	873	24	719	285	141	1790	1795	4.09
56	2	24	651	27	528	174	131	1430	1115	4.74
57	2	25	553	24	382	125	143	987	798	8.66
58	2	26	548	24	386	123	143	1090	813	5.76
59	2	41	583	25	338	159	123	991	1005	4.63
60	2	43	746	28	358	165	128	1080	1299	2.69
61	2	44	878	35	366	176	127	1070	1465	4.46
62	2	46	791	34	371	161	130	993	1470	2.10
63	2	48	647	28	310	110	126	887	1140	0.64
64	2	51	402	14	198	63	100	735	440	5.66
65	2	52	433	16	239	74	82	813	550	4.89
66	2	53	468	17	276	84	81	883	660	3.91
67	2	60	474	19	282	86	60	884	680	4.52
68	2	61	408	14	205	66	159	800	430	3.61
69	2	62	338	28	215	81	65	617	530	6.36
70	2	63	340	27	210	79	58	607	530	6.41
71	2	70	379	27	230	61	73	734	480	5.75
72	2	71	433	30	274	108	62	743	760	5.29
73	2	74	1450	50	597	191	74	1530	2500	2.94
74	2	75	512	24	327	112	87	1050	770	3.66
75	2	77	1230	24	662	630	96	1990	2300	12.60*
76	2	80	539	23	298	113	90	986	800	3.91
77	2	81	552	23	304	114	83	1020	830	3.29
78	2	82	624	19	352	118	89	1420	730	3.08
79	2	84	275	17	205	71	108	658	406	2.82
80	2	86	320	18	230	86	106	751	502	2.19
81	2	87	214	15	68	24	114	357	164	3.79
82	2	88	172	9	88	32	130	321	180	2.82
83	2	89	185	10	114	40	135	397	208	2.65
84	2	90	532	17	407	124	78	1570	660	1.42
85	3	1	500	18	880	312	183	2386	1149	3.80
86	3	2	506	36	800	120	104	2342	875	-1.65

Master #	Ref. #	Well Ref. #	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
87	3	3	422	31	700	300	305	2396	1139	-4.98
88	3	4	427	32	705	305	310	2292	1128	-3.01
89	3	5	299	31	680	288	153	2013	942	0.31
90	3	6	874	47	780	226	366	2437	1439	-0.30
91	3	7	1104	39	640	312	226	2688	1953	-3.68
92	3	8	403	27	780	300	183	2688	750	1.06
93	3	9	920	55	536	350	366	2400	1633	-2.55
94	3	10	920	47	872	293	275	3000	1686	-2.55
95	3	11	736	28	760	274	244	2496	1065	4.01
96	3	12	1012	25	770	259	280	2640	1420	2.34
97	3	13	1449	17	584	226	244	1680	2308	3.30
98	3	14	1960	39	784	106	98	2640	2485	2.85
99	3	15	690	27	656	206	104	2112	977	4.66
100	3	16	500	18	215	122	168	1224	514	0.27
101	3	17	400	23	195	200	178	1241	690	-4.39
102	3	18	361	32	404	103	128	1163	590	2.48
103	3	19	276	18	400	96	188	1049	617	-2.42
104	3	20	329	5	160	101	125	576	527	3.06
105	3	21	242	16	170	96	122	672	417	-0.79
106	3	22	500	18	363	125	151	653	1073	4.40
107	3	23	403	14	256	158	122	1056	604	3.11
108	3	24	449	20	320	72	268	792	746	-0.01
109	3	25	330	23	137	122	151	676	426	5.38
110	3	26	368	20	260	60	268	768	462	1.48
111	3	27	350	20	254	180	158	1248	657	-4.30
112	3	28	276	10	320	144	183	497	960	-0.43
113	3	29	292	15	184	149	102	864	500	1.11
114	3	30	169	4	194	190	143	664	494	4.23
115	3	31	280	23	624	35	174	1685	390	-2.26
116	3	32	345	15	400	144	122	1392	497	2.38
117	3	33	350	22	318	95	186	1067	596	-3.23
118	3	34	345	31	390	120	214	1008	568	5.39
119	3	35	839	0	387	96	136	878	1751	-4.64
120	3	36	590	25	316	105	103	470	1398	-0.19
121	3	37	1600	0	320	182	137	971	2449	4.68

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
122	3	38	242	0	170	104	125	586	497	-1.26
123	3	39	265	20	440	144	104	1536	639	-6.03
124	3	40	299	23	216	110	153	768	462	2.93
125	3	41	350	22	318	95	186	1067	596	-3.20
126	3	42	575	16	180	247	128	912	1136	1.48
127	3	43	186	10	136	42	137	350	341	-1.50
128	3	44	686	20	418	195	214	1461	1125	1.20
129	3	45	391	31	400	144	183	1248	817	-2.38
130	3	46	407	20	233	131	128	1075	639	-2.28
131	3	47	520	70	412	67	140	1510	600	-0.23
132	3	48	380	63	386	46	132	1350	320	2.35
133	3	49	669	55	400	46	110	1730	520	1.65
134	3	50	327	60	390	46	110	1320	366	-0.74
135	3	51	652	46	304	30	256	1710	360	-2.86
136	3	52	510	63	318	36	153	1410	320	2.08
137	3	53	996	114	395	40	199	827	1680	1.00
138	3	54	337	91	348	40	150	988	446	2.77
139	3	55	182	62	285	57	136	757	286	4.30
140	3	56	277	89	355	41	179	975	371	2.48
141	3	57	460	63	337	37	139	1400	305	1.79
142	4	1	516	<0.05	406	137	134	1596	741	-2.17
143	4	2	546	<0.05	438	145	146	1704	830	-3.17
144	4	3	588	<0.05	332	82	37	1132	860	0.56
145	4	4	388	<0.05	285	112	134	1153	559	-2.06
146	4	5	370	<0.05	275	103	116	1129	500	-1.66
147	4	6	353	<0.05	229	176	18	1651	321	-2.92
148	4	7	216	<0.05	421	101	110	1557	204	-1.60
149	4	8	235	<0.05	99	44	226	402	204	2.67
150	4	9	243	<0.05	257	110	183	892	401	-0.60
151	4	10	550	<0.05	383	158	122	1402	940	-1.49
152	4	11	268	<0.05	383	120	177	1386	377	-2.16
153	4	12	394	<0.05	303	111	122	1263	567	-3.37
154	4	13	408	<0.05	301	105	122	1154	584	-1.32
155	4	14	1165	<0.05	601	255	24	2330	2057	-2.54
156	4	15	358	11	302	85	37	1024	484	3.17

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
157	4	16	397	16	388	87	134	1131	547	3.58
158	4	17	241	<0.05	223	66	165	684	272	4.63
159	4	18	885	90	843	353	153	2455	1996	0.88
160	4	19	253	9	54	66	66	365	298	6.23
161	4	20	551	81	522	208	116	2153	921	-2.49
162	4	21	418	45	233	131	24	542	1066	0.02
163	4	22	415	66	304	102	12	1386	655	-4.74
164	4	23	141	16	101	58	214	408	144	0.80
165	4	24	640	<0.05	222	111	171	1108	640	4.45
166	4	25	740	25	297	140	159	745	1443	0.26
167	4	26	328	9	256	205	75	1276	568	0.36
168	4	27	375	<0.05	288	95	146	1066	461	1.19
169	4	28	543	25	669	243	244	2304	816	1.75
170	4	29	76	3	70	24	214	108	119	-1.49
171	4	30	370	54	257	98	128	882	529	3.98
172	4	31	252	33	128	69	153	473	437	-1.63
173	4	32	346	13	143	51	140	591	397	1.64
174	4	33	612	43	336	137	154	974	1140	0.72
175	4	34	1097	<0.05	308	70	116	999	1566	1.44
176	4	35	520	<0.05	235	117	73	859	1044	-4.98
177	4	36	849	<0.05	484	172	116	1561	1418	0.56
178	4	37	694	<0.05	394	163	140	1357	1237	-1.68
179	4	38	1181	<0.05	293	74	92	1071	1492	4.50
180	4	39	370	43	134	40	198	437	554	-1.45
181	4	40	1145	<0.05	549	138	92	1134	2047	3.31
182	4	41	1104	<0.05	688	185	110	1010	2516	1.97
183	4	42	726	<0.05	542	187	109	804	1708	5.20
184	4	43	293	19	174	41	140	553	415	-0.47
185	4	44	363	47	306	74	128	808	676	0.48
186	4	45	540	73	201	24	104	1227	294	2.43
187	4	46	394	<0.05	218	30	92	712	432	3.28
188	4	47	586	28	511	61	98	1340	975	-0.22
189	4	48	888	98	447	60	140	913	1624	10.15*
190	5	1	782	14	624	240	170	2736	994	-1.46
191	5	2	694	12	576	268	164	2880	923	-4.35

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
192	5	3	726	14	512	201	225	2064	852	2.30
193	5	4	713	11	560	144	195	1832	958	1.95
194	5	5	757	60	817	119	73	2180	1078	4.95
195	5	6	848	17	470	174	149	1609	1344	0.83
196	5	7	966	39	521	186	115	1805	1382	3.60
197	5	8	395	11	289	148	213	1343	532	-2.65
198	5	9	385	15	219	137	216	1049	461	1.21
199	5	10	1038	34	404	203	207	1546	1527	2.62
200	5	11	169	4	194	190	143	664	494	4.23
201	5	12	460	7	360	168	82	1152	817	3.59
202	5	13	1076	27	439	151	158	1655	1834	-4.08
203	5	14	463	22	388	90	128	973	773	3.61
204	5	15	283	16	184	114	70	826	533	-3.25
205	5	16	386	20	411	100	134	1188	637	1.25
206	5	17	310	15	428	112	159	1303	520	0.04
207	5	18	471	27	519	148	347	1492	618	4.47
208	5	19	326	23	324	93	134	1056	469	1.55
209	5	20	317	14	302	67	158	825	569	-1.54
210	5	21	470	28	385	143	104	1141	767	5.00
211	5	22	321	16	178	56	176	524	563	-3.15
212	5	23	267	15	245	78	140	664	449	3.12
213	5	24	454	27	330	91	146	1033	674	1.69
214	5	25	448	15	321	84	134	1004	712	-0.45
215	5	26	396	14	385	88	152	1183	634	-1.09
216	5	27	309	14	389	105	122	1303	529	-2.56
217	5	28	356	24	267	62	122	852	547	-0.93
218	5	29	480	0	306	85	106	1146	760	-4.32
219	5	30	297	25	320	33	134	1009	288	1.44
220	5	31	416	16	294	79	134	841	632	2.77
221	5	32	401	23	296	78	140	935	696	-2.70
222	5	33	345	29	164	49	109	555	537	-0.93
223	5	34	212	11	193	59	122	521	430	-2.02
224	5	35	401	25	391	89	140	1179	683	-1.31
225	5	36	416	15	358	92	140	1131	639	0.05
226	5	37	517	65	357	84	134	1168	802	-0.27

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
227	5	38	402	25	470	111	91	1701	421	1.94
228	5	39	539	73	201	24	103	1227	294	2.45
229	5	40	326	53	308	22	146	950	437	-2.66
230	5	41	182	61	285	57	136	757	286	4.28
231	5	42	277	89	355	41	179	975	371	2.48
232	5	43	427	38	314	19	134	1146	334	1.80
233	6	1	467	51	291	125	146	1042	787	0.13
234	6	2	432	59	411	134	159	1330	755	0.22
235	6	3	435	59	395	111	159	1316	741	-1.67
236	6	4	441	55	437	142	146	1143	571	12.27*
237	6	5	453	39	303	130	153	1249	755	-3.40
238	6	6	407	59	559	131	171	1215	932	3.14
239	6	7	646	51	579	198	183	946	1652	3.70
240	6	8	363	43	377	120	159	946	720	3.43
241	6	9	395	27	309	119	146	1210	532	0.61
242	6	10	529	59	717	272	153	1551	1684	0.26
243	6	11	395	39	407	134	165	1124	840	-0.28
244	6	12	386	23	283	115	140	610	883	1.39
245	6	13	297	23	160	85	134	519	564	-0.66
246	6	14	262	20	244	96	128	716	539	-0.28
247	6	15	441	35	196	101	128	596	734	4.12
248	6	16	703	59	575	201	140	860	1911	2.13
249	6	17	577	55	311	117	159	985	915	2.71
250	6	18	363	47	473	142	171	1215	737	3.39
251	6	19	467	43	305	118	171	1105	833	-3.11
252	6	20	483	55	409	111	146	980	893	3.93
253	6	21	595	39	321	157	146	1350	950	-1.31
254	6	22	487	35	435	168	140	1556	734	1.97
255	6	23	359	27	471	151	183	1657	528	-0.16
256	6	24	423	47	481	124	189	1263	865	0.03
257	6	25	416	31	497	141	159	1407	720	2.91
258	6	26	437	47	487	135	140	1436	737	2.42
259	6	27	333	43	353	106	140	879	705	1.73
260	6	28	575	43	956	225	146	1840	1592	3.78
261	6	29	589	82	960	216	146	1878	1602	3.73

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
262	6	30	391	39	265	94	140	826	744	-1.99
263	6	31	1133	113	485	159	165	932	2407	-0.26
264	6	32	681	78	419	202	134	807	1808	-0.63
265	6	33	639	63	569	326	128	1210	2953	-13.31
266	6	34	694	35	583	256	146	764	2315	-1.38
267	6	35	584	78	589	282	153	672	2308	-0.98
268	6	36	131	23	100	73	128	355	277	0.06
269	6	37	308	39	238	260	201	903	900	0.24
270	6	38	308	55	212	241	159	908	904	-1.93
271	7	1	540	73	201	24	104	1227	294	2.43
272	7	2	317	67	350	30	232	778	437	4.54
273	7	3	277	89	355	41	179	975	371	2.48
274	7	4	255	75	288	69	175	960	390	-1.19
275	7	5	897	100	317	28	92	612	1644	-0.77
276	7	6	326	53	308	22	146	951	437	-2.63
277	7	7	327	60	390	46	110	1320	356	-0.38
278	7	8	216	76	309	57	134	789	327	6.10
279	7	9	1465	168	1007	641	67	4099	3487	-3.86
280	7	10	529	70	412	67	140	1510	600	0.17
281	7	11	377	24	421	47	232	1059	525	1.52
282	7	12	888	98	447	60	140	913	1624	0.93
283	7	13	338	31	327	53	98	708	575	5.27
284	7	14	562	39	408	88	122	1260	850	0.77
285	7	15	306	45	271	72	128	734	592	-0.23
286	7	16	281	42	201	61	110	645	464	0.10
287	7	17	341	47	271	79	140	710	652	0.79
288	7	18	291	45	328	49	98	730	592	1.04
289	7	19	362	36	387	53	98	877	620	3.81
290	7	20	369	44	362	68	121	1010	638	-0.20
291	7	21	586	28	511	61	98	1340	975	-0.22
292	7	22	274	22	981	124	85	2026	831	3.34
293	7	23	394		218	30	92	712	432	3.28
294	7	24	293	19	174	41	140	553	415	-0.47
295	7	25	263	33	195	61	171	397	500	3.62
296	7	26	138	19	267	89	129	854	190	3.49

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
297	7	27	176		398	60	98	1279	188	-1.60
298	7	28	346	13	143	51	140	591	397	1.64
299	7	29	249	8	101	61	169	458	255	3.97
300	7	30	258	42	245	43	122	478	653	-3.92
301	7	31	378	36	346	70	159	722	898	-3.16
302	7	32	694		394	163	140	1357	1237	-1.68
303	7	33	1150	33	472	321	51	1680	2385	-1.11
304	7	34	349	12	119	44	58	686	383	-1.94
305	7	35	193	16	135	80	217	336	426	-1.00
306	7	36	1145		549	138	92	1134	2047	3.33
307	7	37	1181		293	74	92	1071	1492	4.51
308	7	38	1097		308	70	116	999	1566	1.45
309	7	39	416		382	114	79	476	1277	-0.72
310	7	40	604		359	116	104	1287	975	-2.11
311	7	41	370	43	134	40	198	437	554	-1.45
312	7	42	1104		688	185	110	1010	2516	1.97
313	7	43	614		812	267	73	1510	1910	1.53
314	7	44	640		222	111	171	1108	640	4.49
315	7	45	235		99	44	226	402	204	2.67
316	7	46	241		223	66	165	684	272	4.63
317	7	47	390		338	88	140	1025	528	3.13
318	7	48	238	19	246	102	183	763	331	5.53
319	7	49	449	37	403	59	140	1039	749	0.48
320	7	50	834	57	686	102	171	1455	1444	4.26
321	7	51	459	52	421	68	116	1105	732	2.50
322	7	52	748		433	111	61	1789	940	-1.18
323	7	53	511		406	105	61	1316	814	-0.24
324	7	54	316		360	59	85	857	707	-3.46
325	7	55	567		507	67	61	1139	1084	0.13
326	7	56	479		416	86	79	1318	798	-2.56
327	8	1	529	70	412	67	140	1510	600	0.17
328	8	2	374	63	371	43	144	1380	320	-0.20
329	8	3	601	49	347	39	134	1620	520	-2.75
330	8	4	327	60	390	46	110	1320	356	-0.38
331	8	5	652	46	304	30	256	1710	360	-2.86

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
332	8	6	513	55	287	31	134	1450	396	-3.54
333	8	7	336	90	340	38	207	1030	442	-0.41
334	8	8	330	47	266	74	134	691	620	1.24
335	8	9	335	48	284	79	134	716	656	1.18
336	8	10	565	39	408	88	122	1260	850	0.89
337	8	11	345	43	257	68	140	708	600	0.79
338	8	12	387	42	263	67	134	784	616	0.93
339	8	13	396	41	185	65	122	703	610	-1.49
340	8	14	341	43	269	72	146	740	620	-0.04
341	8	15	363	47	306	74	128	808	676	0.48
342	8	16	365	44	285	71	110	790	661	0.17
343	8	17	306	45	271	72	128	734	592	-0.23
344	8	18	281	42	201	61	110	645	464	0.10
345	8	19	726	38	339	79	146	945	1360	-3.81
346	8	20	566	42	269	40	140	840	848	-1.48
347	8	21	412	41	445	66	134	1260	602	1.26
348	8	22	369	44	362	68	121	1010	628	0.15
349	9	1	920	55	537	350	366	2398	1632	-2.51
350	9	2	403	27	782	300	183	2685	750	1.12
351	9	3	506	36	802	219	104	2340	875	3.72
352	9	4	920	47	874	293	275	2997	1686	-2.50
353	9	5	1012	25	772	259	280	2637	1419	2.40
354	9	6	736	28	762	274	244	2494	1065	4.07
355	9	7	1448	17	585	226	244	1678	2307	3.34
356	9	8	1104	39	641	312	226	2685	1952	-3.63
357	9	9	500	18	215	122	168	1223	514	0.30
358	9	10	403	14	257	158	122	1055	604	3.17
359	9	11	449	20	321	72	268	791	746	0.04
360	9	12	276	10	321	144	183	497	960	-0.39
361	9	13	345	31	391	120	214	1007	568	5.43
362	9	14	350	22	319	95	186	1066	596	-3.19
363	9	15	350	22	319	95	186	1066	596	-3.14
364	9	16	280	23	625	35	174	1683	390	-2.16
365	9	17	292	15	184	149	102	863	500	1.16
366	9	18	169	4	194	190	143	663	494	4.26

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
367	9	19	345	15	401	144	122	1390	497	2.44
368	9	20	329	5	160	101	125	575	527	3.09
369	9	21	330	23	137	122	151	675	426	5.42
370	9	22	838		388	96	136	878	1751	-4.61
371	9	23	163	14	100	42	137	377	222	-1.33
372	9	24	234	11	146	61	116	419	426	0.15
373	9	25	465	19	364	95	156	1144	835	-3.34
374	9	26	255	12	182	61	137	573	443	-2.28
375	9	27	686	20	419	195	214	1460	1125	1.24
376	9	28	251	12	210	61	146	645	460	-3.82
377	9	29	170	9	118	40	128	341	307	-3.06
378	9	30	186	10	136	42	137	349	341	-1.43
379	9	31	575	16	180	122	128	911	1136	-8.92
380	10	1	556	63	527	449	238	1772	1028	-3.33
381	10	2	800	63	1044	923	171	3645	1840	1.80
382	10	3	984	66	557	682	256	2694	691	15.78*
383	10	4	1090	121	681	581	323	2296	1829	-1.21
384	10	5	435	39	295	318	171	1258	627	-3.66
385	10	6	1159	203	1042	902	311	3564	2343	-0.14
386	10	7	795	98	878	733	445	2896	1595	2.13
387	10	8	368	35	802	594	305	2349	1064	-0.78
388	10	9	575	43	842	729	244	2882	1064	2.94
389	10	10	1058	23	697	461	305	1820	1882	3.18
390	10	11	1104	78	705	637	232	2517	1776	3.32
391	10	12	1195	16	882	777	183	3069	2127	-1.93
392	10	13	621	31	641	582	427	2301	780	5.30
393	10	14	483	16	621	655	183	2589	532	3.49
394	10	15	322	39	641	534	183	2109	798	0.93
395	10	16	874	55	802	850	366	3357	911	3.51
396	10	17	437	27	762	679	214	2685	780	1.21
397	10	18	317	31	667	546	299	2157	670	2.48
398	10	19	414	8	641	485	183	1916	709	5.27
399	10	20	1058	51	641	534	214	2109	1705	1.80
400	10	21	299	31	681	582	153	2301	638	2.22
401	10	22	1150	51	681	818	226	3232	1528	-2.29

Master #	Ref. #	Well Ref. #	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
402	10	23	368	35	922	679	275	2685	1418	-1.01
403	11	1	306	8	244	123	85	1302	294	-1.68
404	11	2	428	12	361	120	238	1460	496	-1.92
405	11	3	726	16	511	201	226	2065	851	1.98
406	11	4	1356	20	599	434	116	3482	2131	-3.83
407	11	5	347	20	333	119	146	1571	177	1.96
408	11	6	1598	23	499	438	214	4558	1634	-5.07
409	11	7	1522	43	405	297	159	2839	1748	0.24
410	11	8	628		493	132	122	1532	915	2.18
411	11	9	731	16	206	126	146	1230	993	-3.02
412	11	10	984		667	219	110	2666	1145	2.14
413	11	11	1117	23	655	159	146	2690	1092	2.84
414	11	12	759	16	321	156	232	1921	638	0.10
415	11	13	1858	55	725	259	153	4039	2187	-3.22
416	11	14	501	8	285	186	134	1566	567	0.44
417	11	15	747	20	289	201	250	1393	993	2.04
418	11	16	570	23	437	201	281	1969	560	1.54
419	11	17	526	63	291	102	116	1398	659	-2.54
420	11	18	602	16	401	128	116	1575	744	0.93
421	11	19	699	20	433	192	104	1681	1205	-2.01
422	11	20	782	20	511	182	177	1801	1205	0.10
423	11	21	740		507	131	122	1551	1219	-0.62
424	11	22	441	20	417	173	177	1489	709	0.40
425	11	23	977	16	461	265	61	1753	1741	0.40
426	11	24	584	16	481	230	116	2305	567	1.77
427	11	25	460	20	619	153	171	1897	851	-2.19
428	11	26	759	59	717	119	73	2181	1078	1.58
429	11	27	1023	23	511	326	189	2137	1918	-2.39
430	11	28	1195	27	511	278	116	2089	1776	2.63
431	12	1	439	14	282	137		565	604	21.70*
432	12	2	301	10	218	96		401	429	22.13**
433	12	3	290	12	228	101		522	520	12.22**
434	12	4	666	20	658	240		1486	855	19.71**
435	12	5	281	9	190	84		372	399	20.51**
436	12	6	913	24	665	298		1455	1230	20.26**

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
437	12	7	890	27	496	227		1006	1601	11.24**
438	12	8	1017	21	646	270		1418	1165	22.78**
439	12	9	653	23	686	247		1401	772	24.24**
440	12	10	1715	31	794	357		1257	2305	22.57**
441	12	11	547	23	463	158		1102	879	11.76**
442	12	12	266	11	181	81		416	436	13.51**
443	12	13	310	11	262	120		560	508	17.05**
444	12	14	389	12	298	134		473	497	28.78**
445	12	15	339	12	239	111		474	498	20.34**
446	12	16	346	12	243	110		475	496	20.98**
447	12	17	672	19	482	214		1143	957	16.86**
448	12	18	389	15	327	151		741	573	18.62**
449	12	19	331	11	232	105		427	450	23.63**
450	12	20	377	12	336	157		474	495	32.06**
451	12	21	304	11	216	98		410	446	20.96**
452	12	22	689	18	713	244		1448	761	25.02**
453	12	23	269	16	163	76		356	343	21.54**
454	12	24	233	14	50	5		44	257	24.30**
455	12	25	343	14	239	109		406	440	26.83**
456	12	26	308	13	202	92		623	610	1.98
457	12	27	609	17	408	185		904	800	20.34**
458	12	28	431	19	310	242		1758	917	-6.73**
459	12	29	475	16	360	161		670	622	24.83**
460	12	30	302	11	241	113		517	497	16.74**
461	12	42	632	41	323	77		753	899	10.82*
462	12	43	1763	123	1351	449		2186	1641	33.47*
463	12	44	1442	97	624	297		2472	2059	4.88*
464	13	1	190	21	81	41	183	249	268	1.24
465	13	2	535	39	109	53	153	455	795	-0.54
466	13	3	438	35	157	74	128	484	674	4.10
467	13	4	319	29	118	70	143	395	526	1.65
468	13	5	279	27	136	75	151	426	480	1.67
469	13	6	270	25	151	71	153	454	412	4.34
470	13	7	251	19	121	59	181	407	327	3.72
471	13	8	259	23	125	73	160	407	419	2.60

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
472	13	9	267	23	146	76	191	443	424	2.82
473	13	10	403	36	120	56	143	381	626	1.98
474	13	11	324	24	165	80	120	516	521	3.66
475	13	12	2280	89	842	596	86	2314	4379	5.30
476	13	13	337	23	187	83	124	567	554	3.12
477	13	14	468	45	206	87	96	587	764	4.81
478	13	15	490	42	151	68	113	487	720	4.71
479	13	16	212	20	94	41	117	324	269	4.68
480	13	17	140	12	60	27	159	165	177	2.35
481	13	18	169	16	68	29	205	193	228	-1.30
482	13	19	313	34	70	38	161	388	340	1.82
483	13	20	214	28	112	51	127	346	331	3.21
484	13	21	277	27	120	63	109	416	449	1.58
485	13	22	458	32	191	87	123	500	786	3.91
486	13	23	210	25	118	49	117	299	380	2.20
487	13	24	222	28	123	49	212	254	456	-2.43
488	13	25	391	29	141	65	125	503	602	1.07
489	13	26	66	9	54	84	88	77	134	29.96*
490	13	27	35	6	28	7	140	27	12	6.00
491	13	28	61	10	59	23	143	127	78	3.74
492	13	29	44	9	102	30	673	158	137	-30.13
493	13	30	33	12	67	22	136	54	92	7.27
494	13	31	359	26	119	79	211	475	488	2.89
495	13	32	780	44	405	158	112	1388	1240	1.89
496	13	33	478	32	243	105	153	747	730	4.61
497	13	34	179	25	65	32	123	200	233	5.70
498	13	35	505	91	161	117	108	530	221	37.60*
499	13	36	374	73	116	92	97	380	676	4.84
500	13	37	186	22	63	42	172	189	253	4.67
501	13	38	278	30	209	40	95	593	345	5.79
502	13	39	100	23	110	30	127	206	197	3.82
503	13	40	53	10	59	21	150	287	78	-19.40*
504	13	41	641	67	175	99	229	696	865	4.34
505	13	42	354	43	103	52	215	330	462	5.05
506	13	43	724	128	386	208	303	823	1608	2.65

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
507	13	44	176	38	112	49	89	728	311	-16.39*
508	13	45	195	39	108	43	117	286	322	4.14
509	13	46	189	42	74	45	218	223	245	5.02
510	13	47	104	33	88	41	109	128	225	9.71
511	13	48	333	98	117	74	194	378	526	5.43
512	13	49	330	51	205	92	91	593	634	2.75
513	13	50	140	15	59	14	78	156	181	4.56
514	13	51	302	17	223	55	130	615	416	4.53
515	13	52	123	13	115	29	104	177	266	3.31
516	13	53	513	23	54	17	10	421	553	4.76
517	13	54	477	50	310	67	93	1079	590	2.81
518	13	55	147	7	130	85	119	457	343	-2.70
519	13	56	118	9	106	59	172	334	232	-2.60
520	13	57	114	12	79	43	130	267	176	0.29
521	13	58	107	7	84	48	150	286	185	-2.46
522	13	59	91	8	69	90	63	484	177	-3.42
523	13	60	42	5	40	16	145	113	17	0.56
524	13	61	252	4	179	83	159	659	418	-2.44
525	13	62	108	16	459	145	166	1931	51	-5.24
526	13	63	50	6	86	37	182	218	70	0.66
527	13	64	99	15	169	98	119	752	158	-2.04
528	13	65	69	4	148	86	127	545	150	-0.27
529	13	66	30	5	101	47	149	273	54	3.23
530	13	67	75	5	126	96	143	398	178	5.86
531	13	68	113	4	173	102	197	692	101	3.59
532	13	69	389	4	336	286	140	1453	966	-2.18
533	13	70	426	4	182	89	110	640	822	-4.51
534	13	71	408	4	166	85	132	541	783	-3.44
535	13	72	8	5	56	13	146	33	16	10.58*
536	13	73	132	3	197	80	114	690	280	-4.07
537	13	74	168	7	325	110	324	882	378	-2.34
538	13	75	211	12	251	157	129	1058	374	0.37
539	13	76	177	4	267	130	130	1149	291	-3.63
540	13	77	149	9	140	78	153	473	336	-4.16
541	13	78	15	5	100	24	227	77	95	-1.61

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
542	13	79	208	9	114	57	160	381	295	2.15
543	13	80	174	9	120	69	165	418	257	2.07
544	13	81	87	7	100	48	207	280	136	-0.50
545	13	82	61	5	78	39	247	165	65	3.16
546	13	83	30	7	52	24		81	55	30.25**
547	13	84	45	7	48	30		47	100	29.52**
548	13	85	108	9	30	49		71	170	25.00**
549	13	86	82	9	22	54		53	150	27.29**
550	13	87	260	12	87	41		269	285	17.27**
551	13	88	450	10	147	116		396	565	20.57**
552	13	89	25	5	62	26		45	95	28.19**
553	13	90	40	7	49	34		46	95	32.58**
554	13	91	30	6	45	36		53	110	22.66**
555	13	92	20	8	41	21		21	74	31.47**
556	13	93	27	7	58	10		13	84	31.52**
557	13	94	28	6	41	15		35	50	36.84**
558	13	95	524	12	161	106		310	998	7.03**
559	13	96	25	5	38	20		32	32	50.48**
560	13	97	30	5	43	16		35	35	48.06**
561	13	98	109	12	52	51		113	250	11.37**
562	13	99	94	12	87	23		125	142	23.37**
563	13	100	43	12	62	24		59	95	29.92**
564	13	101	68	9	68	26		75	150	20.09**
565	13	102	38	12	78	33		110	100	25.22**
566	13	103	55	10	69	34		110	110	24.37**
567	13	104	56	18	65	41		160	100	21.47**
568	13	105	77	14	108	62		220	225	12.90**
569	13	106	47	10	78	28		118	136	14.78**
570	13	107	68	13	76	45		138	145	21.53**
571	13	108	120	28	91	65		198	295	11.96**
572	13	109	170	23	186	64		165	550	8.60**
573	13	110	133	24	74	45		120	280	14.02**
574	13	111	133	45	69	70		165	345	10.14**
575	14	1/1	482	14	619	299	182	2591	532	3.28
576	14	2/1	620	31	639	311	426	2303	780	5.12

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
577	14	3/1	1195	17	879	311	182	3071	2129	-2.06
578	14	4/2	505	36	799	119	103	2341	780	0.08
579	14	5/2	321	31	699	299	304	2159	674	3.69
580	14	6/2	436	27	759	311	213	2687	780	1.02
581	14	7/2	316	30	664	294	299	2158	669	2.23
582	14	8/2	326	32	704	304	309	2169	679	3.99
583	14	9/3	1057	51	639	239	213	2111	1703	1.72
584	14	10/8	298	31	679	287	152	2303	638	2.01
585	14	11/9	1149	51	679	287	225	3236	1526	-2.39
586	14	12/9	367	36	919	431	274	2687	1419	-1.14
587	14	13/5	873	47	779	225	365	2687	1274	-0.67
588	14	14/5	589	27	659	267	304	2103	923	4.07
589	14	15/5	1448	17	583	225	243	1679	2307	3.26
590	14	16/9	597	51	879	407	304	2975	1135	2.79
591	14	17/9	367	36	799	311	213	2351	1064	-0.07
592	14	18/4	735	28	759	273	243	2495	1064	3.95
593	14	19/9	367	36	919	431	274	2687	1419	-1.14
594	14	20/4	1011	25	769	258	279	2639	1419	2.29
595	14	21/2	574	43	839	383	243	2879	1064	2.85
596	14	22/2	402	27	779	299	749	2687	749	-4.51
597	14	23/2	1057	25	695	253	304	1823	1881	3.08
598	14	24/4	919	47	871	292	274	2999	1685	-2.60
599	14	25/2	1103	78	703	345	231	2519	1774	3.26
600	14	26/1	689	27	655	205	103	2111	976	4.59
601	14	27/1	1195	17	879	311	182	3071	2129	-2.06
602	14	28/2	1689	39	783	105	97	2639	2484	-1.78
603	14	29/2	919	55	535	349	365	2399	1632	-2.61
604	14	30/6 7	1103	39	639	311	225	2687	1952	-3.73
605	14	31/12	730	14	575	325	157	2927	993	-2.23
606	14	32/12	1873	21	591	507	194	5135	1632	-0.94
607	14	33/12	1091	16	575	248	185	2903	1170	0.25
608	14	34/12	2357	54	725	258	152	5036	2186	-2.33
609	14	35/12	1735	22	767	411	249	5087	1916	-5.10
610	14	36/11	426	10	359	119	236	1458	496	-1.82
611	14	37/10	305	8	349	122	106	1299	449	-0.64

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
612	14	38/11	482	18	439	215	182	1919	674	-0.76
613	14	39/7	1011	16	551	298	139	2879	1596	-5.33
614	14	40/12	263	3	255	95	224	1016	212	1.99
615	14	41/12	1264	24	563	351	51	3023	1525	2.63
616	14	42/12	1459	13	575	546	279	3647	2129	-1.13
617	14	43/12	3173	24	583	627	103	4079	4898	-1.23
618	14	44/12	5749	43	627	1133	110	6335	9051	-1.75
619	14	45/12	965	9	527	314	121	3311	1064	-3.38
620	14	46/12	730	14	575	325	157	2927	993	-2.23
621	14	47/12	762	22	539	268	101	2639	957	-0.57
622	14	48/12	1379	16	559	354	77	3023	1845	0.50
623	14	49/12	1678	11	559	561	116	3647	2235	2.23
624	14	50/12	1954	23	599	399	156	3479	2803	-1.91
625	14	51/12	626	23	492	131	121	1530	914	2.87
626	14	52/12	1379	12	559	431	182	3359	1890	-1.04
627	14	53/12	3403	20	519	700	121	4799	4436	1.09
628	14	54/12	3219	11	479	828	160	5789	3762	0.66
629	14	55/12	1057	33	575	321	74	2831	1348	1.87
630	14	56/12	1459	20	639	459	169	4799	1419	-3.29
631	14	57/12	2718	28	719	738	182	6095	3265	-1.47
632	14	58/12	2213	47	559	682	92	4559	2945	0.54
633	14	59/12	2069	23	475	548	95	4535	1951	2.69
634	14	60/12	1568	150	687	346	182	4079	1596	0.69
635	14	61/12	1735	22	767	411	249	5087	1916	-5.10
636	14	62/12	1873	21	591	507	194	5135	1632	-0.94
637	14	63/12	1919	21	591	703	182	4814	1916	4.28
638	14	64/12	1126	11	539	348	110	3359	993	2.46
639	14	65/12	1862	14	559	411	110	3359	2271	2.60
640	14	66/12	1482	22	463	479	200	3599	2129	-4.04
641	14	67/12	1540	20	535	581	95	3599	2448	-1.24
642	14	68/12	976	11	547	303	98	2639	1277	1.27
643	14	69/12	1436	15	519	401	116	3599	1703	-1.27
644	14	70/12	1091	16	575	248	185	2903	1170	0.25
645	14	71/12	1770	23	655	517	194	4868	1774	-0.58
646	14	72/12	2069	71	513	617	408	4655	2156	1.13

Master #	Ref. #	Well Ref. #	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	CBE
			(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%
647	14	73/12	1414	59	571	491	347	3215	1756	3.83
648	14	74/12	1126	51	571	303	286	2687	1738	-2.79
649	14	75/12	1391	53	579	480	336	3525	2244	-4.39
650	14	76/11	187	12	543	143	224	1751	283	-0.85
651	14	77/11	530	14	543	200	157	2015	567	5.05
652	14	78/11	238	11	543	191	261	2087	283	-2.08
653	14	79/10	2357	54	725	258	152	5036	2186	-2.33
654	14	80/10	587	8	547	228	92	2759	531	-1.47
655	14	81/10	965	12	519	297	11	3041	851	2.84
656	14	82/10	5749	33	751	709	590	9263	5608	-1.98
657	14	83/10	465	10	455	168	101	1967	425	2.16
658	14	84/10	537	12	547	217	110	2399	638	-0.68
659	14	85/10	932	18	551	222	83	3023	780	0.26

* Charge Balance Error above 10%, data not used in analysis

** Charge Balance Error off due to lack of alkalinity data, data still used still used in analysis

Table 5 Minor Ion data from the NWSAS in µg/l (Mstr.# - Master #)

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
1	21	6	880	416	111	42	260	<5.5	52.3	3.9	2510	1.8	3.1
2	90	3	820	500	99	38	260	5.6	21.8	4.6	2150	2.7	3
3	50	3	870	412	118	38	240	<5.5	28.4	3.9	2250	2.7	3.4
4	60	<3	520	304	29	34	120	<5.5	180.3	6.4	2650	1.8	3.2
5	70	5	460	324	21	48	240	<5.5	104.8	1.8	4580	1.7	4.7
6	70	4	700	417	82	56	190	<5.5	65.6	9.3	2470	1.4	4.1
7	<20	<3	840	342	89	36	140	<5.5	74.3	6.4	1160	0.9	2.5
8	70	12	640	296	57	51	160	<5.5	28.7	10.4	1800	1.3	4
9	60	8	640	472	82	60	160	<5.5	22.9	10.4	2300	0.7	3.4
10	250	18	500	424	52	81	180	<5.5	42.7	16.7	2140	0.9	1.7
11	2750	84	440	836	52	128	310	<5.5	18	13.1	3350	1.6	0.2
12	390	30	500	540	53	135	250	<5.5	20.4	16.4	3090	1.2	<0.2

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
13	370	46	460	1020	62	160	360	<5.5	17.6	18.2	4420	0.9	<0.2
14	500	34	530	1010	67	142	340	<5.5	17.5	16.1	3910	1	<0.2
15	340	34	540	910	62	182	380	<5.5	16.5	17.5	4090	1.1	<0.2
16	230	27	500	584	55	119	220	<5.5	16.4	15.9	3210	0.5	<0.2
17	160	34	600	790	54	188	370	<1.0	n.d.	17.6	5100	<0.6	<0.3
18	1330	213	700	1270	71	307	1040	<5.5	16.2	14.9	4720	0.3	<0.2
19	320	46	490	915	79	173	420	<5.5	12.5	17.2	5630	0.7	<0.2
20	220	48	560	595	55	147	260	<5.5	16.3	15.2	3730	0.8	<0.2
21	1080	41	580	1100	153	70	190	<5.5	80.7	15.9	2650	0.2	<0.2
22	370	27	560	581	84	82	250	<5.5	17	14.3	2840	0.2	<0.2
23	260	22	550	497	87	75	210	<5.5	12.3	14.8	2390	<0.2	<0.2
24	100	6	950	635	82	58	240	<5.5	50.1	6.1	2190	<0.2	3.4
25	<20	11	940	492	86	37	230	<5.5	60.6	6.1	1870	0.2	3.2
26	620	24	430	765	51	114	260	3.8	36.3	12.8	3500	<0.6	<0.1
27	460	29	420	840	52	124	300	<0.5	39.7	13.5	3830	<0.6	<0.1
28	16300	60	1000	2020	59	252	860	17.1	17.5	40.6	6870	<0.92	<0.7
29	1360	84	600	696	47	170	580	6	85	35.2	6210	<0.92	<0.7
30	1650	73	1200	29900	645	494	3640	134	102	44.4	18800	8.4	<0.7
31	2300	100	6000	1590	61	202	740	21.1	46.4	29.5	7010	<0.92	<0.7
32	3380	266	500	830	50	147	460	12.3	2975.2	35.7	6390	<0.92	<0.7
33	470	78	650	1050	60	187	650	6.9	<3.4	29.3	8110	<0.92	<0.7
34	15000	400	500	810	44	157	480	30.7	20.8	34.2	7450	<0.92	<0.7
35	480	561	400	7170	21	797	1120	12.7	<3.4	87	8190	<0.92	<0.7
36	4110	187	700	1050	60	244	540	4.6	10.9	55.5	12200	<0.92	<0.7
37	570	30	600	736	50	160	320	7.9	<3.4	17	4620	<0.92	<0.7
38	1230	36	700	760	50	168	340	10.5	<3.4	16.7	4560	<0.92	<0.7
39	3320	105	500	1530	66	200	710	4.9	<3.4	16.4	6650	<0.92	<0.7
40	810	23	500	1100	62	162	420	3.8	<3.4	14.4	4080	<0.92	<0.7
41	1060	27	500	1100	63	166	500	7.4	8.7	14.2	4410	<0.92	<0.7
42	13500	743	300	1140	63	172	480	27.1	35.8	12.8	2920	<0.92	<0.7
43	810	25	600	984	60	148	400	3.6	<3.4	16.2	4280	<0.92	<0.7
44	950	20	600	846	50	165	360	5.4	<3.4	16.2	4680	<0.92	<0.7
45	280	14	600	912	53	152	370	3.2	7.1	15.4	4660	<0.92	<0.7
46	690	23	700	720	52	151	330	3.3	<3.4	17.6	4370	<0.92	<0.7
47	17000	412	400	672	55	150	330	36.7	66	16.5	3870	1.1	<0.7

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
48	<20	444	500	783	117	144	450	3.6	<3.4	32.2	6670	<0.92	<0.7
49	3600	65	600	776	49	149	290	3.1	4.7	16.7	4460	<0.92	<0.7
50	0.08	0.007	2.13	740	0.147	91	380	<5.5	30.4	6.3	8,700	1	5.2
51	0.12	0.006	1.76	720	0.0928	117	360	<5.5	26.1	9.3	6,490	1.3	3.8
52	0.07	0.007	1.8	900	0.0747	121	350	<5.5	30.1	8.4	7,760	0.9	3.6
53	0.05	<0.004	2.1	1130	0.0934	142	460	<5.5	20.4	9.2	7,740	1	3.4
54	0.04	<0.005	1.91	1400	0.0955	172	460	<5.5	15	9.8	8,940	0.4	5
55	0.07	<0.007	2.26	1780	0.163	174	530	<5.5	21.7	8.5	14,000	1.2	7.7
56	0.09	<0.004	2.23	1250	0.111	158	530	<5.5	18.6	10.3	9,180	0.5	5.4
57	0.07	0.008	2.33	880	0.0891	141	510	<5.5	25.4	8.3	6,820	0.9	4.2
58	0.05	<0.004	2.75	510	0.0902	140	510	<5.5	16.2	2.2	6,890	0.6	5.6
59	<0.02	0.005	1.6	840	0.177	89	370	<5.5	100.1	8.2	6,220	0.2	3.2
60	0.03	<0.003	1.4	1860	0.198	102	430	<5.5	18.6	7.9	5,790	0.5	4
61	0.03	<0.003	1.4	990	0.122	127	490	<5.5	22.1	8.8	5,730	0.4	4
62	0.06	<0.003	1.25	740	0.119	133	520	<5.5	17.4	8.7	5,560	<0.2	4.2
63	0.04	0.004	1.28	1760	0.124	110	430	<5.5	27.2	6.9	4,790	<0.2	4
64	0.04	<0.003	0.59	700	0.092	78	260	2.5	77.7	3.2	2,820	<0.6	6.1
65	0.12	0.004	0.61	800	0.0955	82	280	3.2	54.9	3.4	3,500	0.6	4.9
66	0.04	0.005	0.6	930	0.104	87	310	<0.5	66	4.8	4,260	<0.6	4.8
67	0.16	0.018	0.66	1050	0.098	92	330	<0.5	69.5	5	4,390	<0.6	4.2
68	0.08	0.004	0.58	680	0.098	82	230	1.6	45.3	3.2	2,790	<0.6	6.4
69	<0.02	<0.003	1.35	620	0.065	84	320	0.8	37.8	7.4	6,550	<0.6	3.1
70	<0.02	0.003	1.44	595	0.065	81	330	0.9	32.8	5.8	6,080	<0.6	3.5
71	0.09	0.004	1.6	770	0.046	60	370	2	59.6	8.5	6,640	<0.6	2.9
72	<0.02	<0.003	1.32	910	0.075	94	370	1	33.8	7.1	8,420	<0.6	3.6
73	<0.02	0.018	1.7	2960	0.11	217	700	5.8	39.2	16.5	9,920	<0.6	5
74	0.03	<0.003	1.95	113	0.0585	99	350	3	51.6	7.9	8,560	<0.6	4.1
75	<0.02	<0.003	2.5	1900	0.16	175	530	2.2	41.1	8.2	12,500	<0.6	7.7
76	0.06	<0.003	2.3	120	0.0735	111	460	1	36.6	7.3	6,580	<0.6	3
77	0.08	0.004	2.3	121	0.0735	115	460	1	39.7	7.1	6,600	<0.6	3.3
78	0.05	<0.003	2.6	131	0.0975	142	720	1.4	35.5	7.4	6,710	<0.6	4.1
79	<0.02	<0.003	0.96	410	0.0612	60	230				5,430		
80	<0.02	<0.003	1.08	490	0.0604	70	230				6,540		
81	<0.02	<0.003	0.85	260	0.061	40	240				1,370		
82	<0.02	<0.003	0.54	250	0.0373	50	160				933		
83	<0.02	<0.003	0.55	290	0.0371	40	150				1,280		
84	<0.02	<0.003	0.41	1060	0.0828	60	110				4,730		
85				800							6.2		

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
86				800							7.8		
87				1500							9.6		
88				1200							8.9		
89				1000							9		
90				2100							9.5		
100				500							4.4		
101				900							5.7		
102				700							5.3		
103				700							5.3		
104				400							1.9		
105				500							2		
106				3700							5		
131				2000							6.9		
132				700							6.2		
133				1600							7		
134				800							6.4		
135				1000							8.1		
136				800							7.4		
327						252							
328						170							
329						202							
330						147							
331						187							
332						157							
333						244							
334						160							
335						168							
336						200							
337						162							
338						166							
339						172							
340						148							
341						165							
342						152							
343						151							
344						150							
345						279							
346						214							

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
347						190							
348						165							
431			700	600									
432			700	500									
433			800	500									
434			1700	1300									
435			700	500									
436			1200	1200									
437			700										
438			2000	1400									
439			1600	1200									
440			1000	2000									
441			1700	2200									
442			700	500									
443			900	500									
444			800	500									
445			800	500									
446			700	500									
447			1000	1100									
448			800	600									
449			700	500									
450			800	600									
451			700	500									
452			1900	1200									
453			1100	400									
454			400	600									
455			700	500									
456			700	700									
457			600	900									
458			1400	1300									
459			900	700									
460			800	500									
461			400	1800									
462			1900	1900									
463			600	1600									
464			1150			100					960		
465			1010	2840		200					1480		
466			1200	1980		100					1880		

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
467			1000	2200		100					1420		
468			910	2090		100					1680		
469			970	1980		200					1680		
470			1070			200					1440		
471			1010	1980		200					480		
472			1040	1970		200					2000		
473			980	2420		300					1120		
474			1200	2010		100					2240		
475			1060	3840		2900					17260		
476			980	2020		100					2730		
477			1060	2050		100					2660		
478			1070	2340		100					1880		
479			1020	1940		100					1020		
480			840			100					630		
481			940			100					740		
482			1270	2030		100					890		
483			1020			100					1360		
484			1170	2340		100					1610		
485			1110	2330		100					2110		
486			960	2010		100					1220		
487			890	2070		100					1310		
488			1050	2200		100					1630		
489			760			100					470		
490			630			0					200		
491			850			100					520		
492			480			100					730		
493			650	1890		100					590		
494			1320	2070		100					1340		
495			1410	2440		200					5660		
496			1300	2100		100					3090		
497			1050	1960		100					680		
498			1880	2360		100					2750		
499			1840	2270		100					2070		
500			1360	2060		100					800		
501			1600	2000		100					2420		
502			690			100					800		
503			710			100					450		
504			780	2320		100					2100		

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
505			1010	2010		100					1150		
506			2410	2890		100					3320		
507			1020	2060		100					960		
508			1600	2020		100					1400		
509			1820	2120		100					900		
510			1410	2050		100					1100		
511			1550	2290		100					1740		
512			1130	2350		100					3120		
513			1760	2000		100					580		
514			1380	2020		100					2150		
515			1420	1950		100					1220		
516			1500	2130		100					570		
517			1800	2100		100					3710		
518			900	2900		500					800		
519			800	2700		500					700		
520			1000	2700		500					900		
521			1000			500					500		
522			1000			500					1700		
523			1100			600					600		
524			700	2800		600					200		
525			1300	2700		2400					6200		
526			400	2600		600					500		
527			900	2700		1900					2500		
528			700	2700		600					300		
529			600	2700		600					500		
530			700	2700		0					200		
531			800	2600		600					300		
532			1000	3400		600					300		
533			700	2700		600					200		
534			700	2800		600					100		
535			600			600					600		
536			1100	2900		600					200		
537			900	3300		500					3800		
538			1000	2800		500					4200		
539			600	2800		500					800		
540			800	2800		500					1100		
541			1400	2600		500					1100		
542			700	2800		500					1000		

Mstr. #	Fe tot.	Mn	F	Br	I	Li	B	Cu	Zn	Rb	Sr	Pb	U
543			800	2700		500					800		
544			700	2700		500					1300		
545			600			500					900		
551			300										
558			100										
559			100										
560			100										
570			100										
573			100										

Table 6 Stable isotope and saturation indices data of the NWSAS

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
1	1	1	-68	-8.3			0.7085	-0.03	-0.8	-5.69
2	1	2	-64	-8.6	0.9	-7.84		-0.07	-0.89	-5.83
3	1	3	-63	-8.5	1.6	-7.69		0.14	-0.82	-5.79
4	1	5	-53	-7.7	54		0.7080	0.08	-0.76	-6.55
5	1	6	-40	-6.3	60		0.7078	0.42	-0.35	-6.11
6	1	7	-58	-8.1			0.7082	0.1	-0.9	-5.88
7	1	8	-59	-8.1	0.5	-8.63	0.7084	0.25	-1.19	-6.21
8	1	9	-61	-8.4				0.26	-1.02	-6.04
9	1	10	-60	-8.3				0.35	-0.9	-5.69
10	1	12	-58	-7.8	0.8	-10.89		0.63	-0.71	-5.8
11	1	14	-62	-8.2				0.69	-0.71	-5.74
12	1	16	-60	-8.0			0.7082	0.59	-0.68	-5.63
13	1	17	-59	-8.5	0	-10.05		0.73	-0.71	-5.59

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
14	1	18	-61	-8.4				0.58	-0.73	-5.61
15	1	20	-61	-8.3			0.7081	0.59	-0.62	-5.43
16	1	22	-61	-8.4	0.5	-10.46		0.88	-0.8	-5.73
17	1	37	-61	-7.8			0.7081	0.81	-0.65	-5.44
18	1	38	-60	-8.0			0.7083	0.43	-0.64	-5.26
19	1	39	-63	-8.1			0.7081	0.19	-0.61	-5.58
20	1	40	-57	-7.7			0.7082	0.49	-0.67	-5.58
21	1	42	-61	-7.6			0.7084	0.65	-0.84	-5.62
22	1	45	-64	-9.1	3.7	-9.1	0.7084	0.9	-0.85	-5.63
23	1	47	-63	-7.2				0.65	-0.93	-5.65
24	1	49	-60	-7.9	1.6	-7.5	0.7085	0.46	-0.95	-5.49
25	1	50	-63	-8.9				0.5	-1	-5.7
26	1	78	-61	-8.4	0.5	-10.46		0.1	-0.77	-5.77
27	1	79	-59	-8.2				0.27	-0.72	-5.81
28	1	101	-58	-7.1	5.80±1.00			0.75	-0.23	-5.29
29	1	102	-50	-7.7			0.7083	0.6	-0.25	-5.7
30	1	103	-57	-7.0	8.80±0.60	-7.85	0.7078	0.57	-0.21	-3.57
31	1	104	-62	-7.7	2.50±0.60	-9.05	0.7084	0.61	-0.26	-5.29
32	1	105	-61	-7.6			0.7083	0	-0.25	-5.7
33	1	106	-67	-6.8	7.30±0.80	-11		1.55	-0.31	-5.41
34	1	107	-57	-6.8				0.82	-0.35	-5.24
35	1	108	-62	-7.5	6.40±0.50	-10.3	0.7094	0.8	-0.94	-4.61
36	1	109	-53	-8.0				0.33	-0.4	-5.53
37	1	110	-60	-8.8				0.52	-0.62	-5.45
38	1	111	-57	-7.6				0.61	-0.59	-5.42
39	1	112	-64	-8.3	3.70±0.80	-11.43	0.7081	0.74	-0.33	-5.07
40	1	113		-8.4	2.20±0.90	-10.77		0.99	-0.62	-5.43

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
41	1	114	-64	-8.4	1.50±0.90	-10.44	0.7082	0.8	-0.58	-5.38
42	1	115		-8.3			0.7082	0.34	-0.73	-5.38
43	1	116	-59	-8.6	5.30±0.80	-11.49	0.7082	0.3	-0.61	-5.39
44	1	117	-59	-8.1			0.7082	0.47	-0.53	-5.37
45	1	118	-61	-8.5				0.53	-0.55	-5.4
46	1	119	-58	-8.1				0.41	-0.58	-5.5
47	1	120	-59	-8.2				0.48	-0.71	-5.63
48	1	121	-60	-8.4			0.7083	-0.19	-0.35	-5.26
49	1	122	-59	-8.4	6.6±1.5	-9.5		0.9	-0.6	-5.42
50	2	11	-72	-9.2				0.38	-0.26	-5.35
51	2	13	-60	-7.1				0.8	-0.3	-5.18
52	2	15	-59	-7.3				0.09	-0.31	-5.09
53	2	19	-50	-5.1	2.4±0.7	-4.7		0.41	-0.29	-4.85
54	2	21	-58	-6.7	4.0±0.5	-5.1		0.3	-0.27	-4.63
55	2	23	-55	-7.1				0.43	-0.1	-4.53
56	2	24	-50	-7.6				0.51	-0.22	-4.84
57	2	25	-47	-4.9				0.49	-0.42	-5.04
58	2	26	-48	-5.6	0.0±1.5	-6.44		0.49	-0.38	-5.04
59	2	41	-60	-7.7				0.17	-0.49	-4.92
60	2	43	-66	-7.2				0.36	-0.46	-4.71
61	2	44	-65	-7.3				0.03	-0.47	-4.59
62	2	46	-70	-7.5	8.4±0.8	-7.6		0.16	-0.49	-4.64
63	2	48	-64	-7.4				0.32	-0.54	-4.82
64	2	51	-61	-6.9				-0.89	-0.69	-5.41
65	2	52	-56	-6.8	24.7±1.0	-7		-0.77	-0.6	-5.29
66	2	53	-58	-6.7	31.4±3.7	-9.5		-0.2	-0.55	-5.2
67	2	60	-57	-6.4				-0.49	-0.54	-5.18
68	2	61	-59	-6.6				0.04	-0.66	-5.43

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
69	2	62	-53	-5.3	28.0±0.8	-6.56		-0.49	-0.73	-5.41
70	2	63	-53	-5.3				-0.4	-0.74	-5.41
71	2	70	-48	-5.1				-0.31	-0.63	-5.4
72	2	71	-52	-5.3				-0.14	-0.62	-5.16
73	2	74	-59	-7.4				0.39	-0.25	-4.19
74	2	75	-62	-7.6	38.9±2	-9		0.27	-0.46	-5.1
75	2	77	-53	-7.3				-0.17	-0.2	-4.29
76	2	80	-49	-4.9				0.06	-0.52	-5.07
77	2	81	-47	-5.9				-0.06	-0.5	-5.04
78	2	82	-56	-6.9				0.2	-0.34	-5.05
79	2	84	-55	-5.5	24.1±0.8	-7.4		-0.28	-0.7	-5.6
80	2	86	-53	-5.4	22.7±0.7	-7.5		0.22	-0.64	-5.46
81	2	87	-58	-5.6				0.12	-1.24	-6.07
82	2	88	-64	-6.5				0.15	-1.19	-6.13
83	2	89	-61	-6.8	42.5±1.5	-6.6		0.31	-1.03	-6.05
84	2	90	-69	-8.6				0.3	-0.24	-5.14
85	3	1	-49	-5.1				-0.15	0.08	-4.97
86	3	2	-44	-3.9				0.93	0.1	-5.07
87	3	3	-49	-5.3				0.63	0.02	-5.03
88	3	4	-42	-3.5				0.85	0	-5.03
89	3	5	-46	-4.6				0.87	-0.04	-5.26
90	3	6	-44	-5.0				1.19	0.04	-4.63
91	3	7	-45	-4.4				0.26	-0.03	-4.41
92	3	8	-49	-4.8				0.45	0.1	-5.24
93	3	9	-47	-4.9				0.15	-0.12	-4.55
94	3	10	-41	-3.2				0.42	0.13	-4.55
95	3	11	-42	-3.5				0.47	0.05	-4.83
96	3	12	-43	-3.6				1.11	0.06	-4.57
97	3	13	-43	-3.6				0.63	-0.21	-4.2
98	3	14	-39	-4.7				-0.32	0.05	-4.05
99	3	15	-29	-2.2				0.16	-0.02	-4.88
100	3	16	-49	-5.3				0.39	-0.56	-5.3

Master #	Ref. #	Well Ref. #	δ²H	δ¹⁸O	¹⁴C	δ¹³C	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
101	3	17	-49	-5.1				0.27	-0.62	-5.25
102	3	18	-48	-5.0				0.25	-0.33	-5.36
103	3	19	-48	-5.0				0.63	-0.36	-5.46
104	3	20	-44	-3.9				0.72	-0.88	-5.43
105	3	21	-51	-5.9				0.33	-0.79	-5.66
106	3	22	-51	-6.0				0.8	-0.62	-4.98
107	3	23	-47	-4.8				0.12	-0.54	-5.29
108	3	24	-48	-4.8				0.91	-0.53	-5.16
109	3	25	-46	-4.8				0.4	-0.9	-5.52
110	3	26	-43	-4.1				0.89	-0.59	-5.45
111	3	27	-45	-4.8				0.31	-0.5	-5.32
112	3	28	-47	-4.6				1.05	-0.75	-5.26
113	3	29	-45	-4.1				0.57	-0.71	-5.51
114	3	30	-52	-5.7				-0.05	-0.8	-5.74
115	3	31	-54	-6.1				0.2	-0.04	-5.66
116	3	32	-50	-5.4				0.17	-0.29	-5.47
117	3	33	-45	-4.0				-1.41	-0.43	-5.36
118	3	34	-49	-5.0				0.61	-0.39	-5.39
119	3	35	-52	-6.0				1.01	-0.52	-4.56
120	3	36	-48	-6.1				0.05	-0.79	-4.78
121	3	37	-49	-5.7				0.58	-0.65	-4.16
122	3	38	-47	-4.8				0.37	-0.85	-5.59
123	3	39	-47	-4.8				0.3	-0.22	-5.47
124	3	40	-49	-5.6				0.07	-0.67	-5.53
125	3	41	-45	-4.2				-0.99	-0.43	-5.36
126	3	42	-50	-5.5				0.1	-0.8	-4.87
127	3	43	-46	-5.1				-1.26	-1.02	-5.82
128	3	44	-50	-5.5				-0.49	-0.31	-4.82
129	3	45	-54	-6.2				0.33	-0.34	-5.2
130	3	46	-46	-4.5				0.62	-0.56	-5.27
131	3	47	-58	-7.1				0.75	-0.23	-5.3
132	3	48	-58	-7.5				0.46	-0.25	-5.69
133	3	49	-62	-7.4				0.33	-0.2	-5.25
134	3	50	-61	-7.6				0.41	-0.25	-5.69
135	3	51	-61	-6.8				1.55	-0.31	-5.41

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
136	3	52	-59	-7.4				0.58	-0.32	-5.55
137	3	53	-57	-7.2				0.64	-0.52	-4.55
138	3	54	-55	-7.4				0.37	-0.37	-5.59
139	3	55	-57	-7.3				0.31	-0.52	-6.02
140	3	56	-56	-7.4				0.45	-0.37	-5.75
141	3	57	-60	-7.5				0.25	-0.29	-5.63
142	4	1	-49	-6.7				0.45	-0.24	-5.11
143	4	2	-48	-6.8	11.2	-4.5		0.22	-0.21	-5.04
144	4	3	-58	-8.3				0.21	-0.41	-4.99
145	4	4	-54	-7.2	30.2	-7.3		0.19	-0.45	-5.34
146	4	5	-49	-7.0	12.5	-6.2		-0.12	-0.45	-5.4
147	4	6	-56	-7.5				-0.23	-0.42	-5.62
148	4	7	-25	-5.3				0.37	-0.18	-6.02
149	4	8	-39	-6.7	11.4	-8.1		0.23	-1.1	-5.95
150	4	9	-32	-5.8	37	-6.6		0.08	-0.54	-5.67
151	4	10	-50	-6.9	11.4	-5.2		0.24	-0.31	-4.97
152	4	11	-33	-6.1	43	-7.8		0.18	-0.27	-5.67
153	4	12	-52	-7.0	9.5	-6.5		0.34	-0.39	-5.33
154	4	13	-52	-7.3				0.25	-0.42	-5.3
155	4	14	-54	-7.7				-0.03	-0.08	-4.36
156	4	15	-46	-6.6				-0.12	-0.44	-5.43
157	4	16	-52	-7.3	11	-5.5		0.48	-0.34	-5.36
158	4	17	-43	-6.7	18.1	-7		0.67	-0.65	-5.84
159	4	18	-37	-6.0				1.03	0.05	-4.48
160	4	19	-33	-5.5				-0.33	-1.38	-5.74
161	4	20	-59	-8.1				0.33	-0.07	-4.99
162	4	21	-60	-8.0				0.22	-0.8	-5.02
163	4	22	-55	-7.9				-0.05	-0.36	-5.24
164	4	23	-38	-6.2				-0.15	-1.07	-6.31
165	4	24	-47	-6.8	16.9	-6.7		0.81	-0.57	-5.06
166	4	25						0.6	-0.66	-4.67
167	4	26						-0.08	-0.48	-5.4
168	4	27						-0.01	-0.44	-5.43
169	4	28						1.11	0.01	-5.06
170	4	29						0.95	-1.64	-6.62

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
171	4	30						0.49	-0.55	-5.37
172	4	31						0.36	-0.98	-5.59
173	4	32	-46	-6.9				-0.4	-0.86	-5.51
174	4	33	-57	-7.7	5	-9.9		0.96	-0.51	-4.87
175	4	34	-67	-8.8	16.5	-10		0.33	-0.55	-4.49
176	4	35	-63	-8.1				-0.12	-0.63	-4.93
177	4	36	-50	-7.0				0.56	-0.26	-4.65
178	4	37	-47	-7.0				0.89	-0.33	-4.76
179	4	38	-68	-8.9				0.48	-0.54	-4.48
180	4	39	-61	-7.9				1.11	-1.02	-5.39
181	4	40	-66	-8.6	3.8	-10.5		0.25	-0.33	-4.35
182	4	41	-64	-8.4	5.1	-10.7		0.47	-0.34	-4.3
183	4	42	-64	-8.3				0.13	-0.45	-4.61
184	4	43	-47	-7.0	22.5	-7.6		0.26	-0.79	-5.56
185	4	44	-59	-8.1				0.5	-0.53	-5.37
186	4	45	-49	-7.0				1.11	-0.51	-5.57
187	4	46	-50	-7.2	10.9	-7.8		0.42	-0.61	-5.4
188	4	47	-59	-7.9				0.15	-0.23	-5
189	4	48	-63	-8.2				0.86	-0.45	-4.61
190	5	1	-49	-6.7				0.9	0.02	-4.83
191	5	2	-52	-7.0				1.03	0	-4.92
192	5	3	-45	-7.3				0.34	-0.13	-4.92
193	5	4	-48	-7.2				0.74	-0.12	-4.88
194	5	5	-41	-6.2	24.9			0.68	0.05	-4.82
195	5	6	-51	-7.3	15.15			0.71	-0.27	-4.69
196	5	7	-49	-6.7	11.9			0.86	-0.2	-4.62
197	5	8	-46	-6.8				0.41	-0.4	-5.35
198	5	9	-45	-7.0	17.5			0.4	-0.59	-5.43
199	5	10	-41	-5.7	34			0.52	-0.34	-4.52
200	5	11	-52	-5.7	17.8			-0.05	-0.8	-5.74
201	5	12	-48	-5.0	17			0.29	-0.41	-5.12
202	5	13	-45	-6.9				0.39	-0.29	-4.44
203	5	14	-45	-4.9				0.1	-0.41	-5.15
204	5	15	-40	-4.3				-0.28	-0.71	-5.49
205	5	16	-45	-5.1				0.17	-0.31	-5.3

Master #	Ref. #	Well Ref. #	δ²H	δ¹⁸O	¹⁴C	δ¹³C	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
206	5	17	-50	-6.1	10.4			0.18	-0.27	-5.49
207	5	18	-47	-5.5				0.23	-0.2	-5.24
208	5	19	-44	-5.3				0.12	-0.42	-5.5
209	5	20	-43	-4.4				0.29	-0.51	-5.42
210	5	21	-45	-5.0				0.04	-0.38	-5.14
211	5	22	-42	-4.2				0.25	-0.84	-5.4
212	5	23	-42	-4.1				0.4	-0.64	-5.58
213	5	24	-45	-4.9				-0.25	-0.44	-5.2
214	5	25	-43	-4.6				0.66	-0.45	-5.18
215	5	26	-46	-5.0				0.31	-0.33	-5.29
216	5	27	-48	-5.5				0	-0.3	-5.48
217	5	28	-43	-4.1				0	-0.54	-5.38
218	5	29	-48	-5.2	4.4			0.05	-0.44	-5.15
219	5	30	-46	-4.7	3.2			0.25	-0.38	-5.73
220	5	31	-45	-4.6				0.27	-0.53	-5.26
221	5	32	-46	-4.5	5.8			0.18	-0.5	-5.24
222	5	33	-49	-5.2	2.1			0.21	-0.83	-5.38
223	5	34	-50	-5.9				0.34	-0.79	-5.69
224	5	35	-44	-5.0				0.34	-0.33	-5.25
225	5	36	-45	-5.2				0.18	-0.38	-5.27
226	5	37	-45	-5.4				0.51	-0.38	-5.08
227	5	38	-58	-7.5	0.48			0.81	-0.16	-5.55
228	5	39	-59	-7.4	0.38			1.1	-0.51	-5.57
229	5	40	-55	-7.4	0.27			1.27	-0.4	-5.62
230	5	41	-57	-7.3	0.42			0.28	-0.53	-6.01
231	5	42	-56	-7.4	0.69			0.44	-0.37	-5.75
232	5	43	-60	-7.5				0.85	-0.34	-5.62
233	6	1	-45	-4.2				-0.39	-0.51	-5.13
234	6	2	-48	-4.9				-0.18	-0.31	-5.19
235	6	3	-52	-4.9				-0.25	-0.31	-5.19
236	6	4	-49	-5.0				-0.54	-0.34	-5.3
237	6	5	-50	-5.0				-0.45	-0.43	-5.16
238	6	6	-48	-4.9				0.04	-0.24	-5.13
239	6	7	-44	-3.9				-0.25	-0.39	-4.69
240	6	8	-42	-4.0				-0.12	-0.44	-5.28

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
241	6	9	-46	-4.6				-0.27	-0.42	-5.37
242	6	10	-51	-5.1				-0.22	-0.15	-4.78
243	6	11	-47	-4.8				-0.24	-0.37	-5.18
244	6	12	-54	-5.8				-0.26	-0.7	-5.17
245	6	13	-51	-5.9				-0.41	-0.91	-5.45
246	6	14	-50	-5.8				-0.31	-0.65	-5.53
247	6	15	-50	-5.4				-0.46	-0.82	-5.17
248	6	16	-49	-5.9				0	-0.44	-4.61
249	6	17	-47	-4.7				-0.32	-0.51	-4.98
250	6	18	-51	-5.0				-0.38	-0.28	-5.27
251	6	19	-48	-4.5				-0.39	-0.47	-5.11
252	6	20	-47	-4.7				-0.29	-0.41	-5.07
253	6	21	-51	-5.2				-0.38	-0.42	-4.96
254	6	22	-54	-6.2				-0.21	-0.26	-5.16
255	6	23	-54	-6.1				-0.09	-0.19	-5.43
256	6	24						-0.02	-0.27	-5.14
257	6	25	-48	-4.9				-0.13	-0.22	-5.23
258	6	26	-48	-5.0				-0.21	-0.23	-5.21
259	6	27	-45	-4.5				-0.27	-0.48	-5.32
260	6	28	-51	-7.4				-0.04	0.01	-4.78
261	6	29	-52	-7.3				0.01	0.01	-4.78
262	6	30	-44	-3.9				-0.36	-0.59	-5.22
263	6	31						-0.17	-0.48	-4.31
264	6	32	-50	-6.0				-0.13	-0.56	-4.63
265	6	33						-0.3	-0.36	-4.46
266	6	34	-42	-4.1				-0.09	-0.52	-4.54
267	6	35	-48	-6.1				-0.12	-0.55	-4.6
268	6	36						-0.69	-1.16	-6.08
269	6	37	-43	-4.6				-0.27	-0.69	-5.25
270	6	38						-0.35	-0.72	-5.25
271	7	1	-48	-7.0				1.11	-0.51	-5.57
272	7	2	-48	-7.1				0.43	-0.43	-5.63
273	7	3	-56	-7.4				0.45	-0.37	-5.75
274	7	4	-51	-7.5				0.52	-0.46	-5.67
275	7	5	-50	-7.0				0.51	-0.65	-4.63

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
276	7	6	-49	-6.7				1.27	-0.4	-5.62
277	7	7	-61	-7.6				0.39	-0.25	-5.7
278	7	8	-54	-7.8				0.24	-0.47	-5.91
279	7	9	-53	-7.3				0.17	0.13	-4.15
280	7	10	-58	-7.1				0.71	-0.23	-5.29
281	7	11	-61	-8.5				1.22	-0.33	-5.45
282	7	12	-63	-8.2				0.86	-0.45	-4.61
283	7	13	-60	-8.4				1.19	-0.52	-5.47
284	7	14	-64	-8.3				0.76	-0.33	-5.07
285	7	15	-58	-8.1				0.44	-0.58	-5.5
286	7	16	-59	-8.2				0.53	-0.71	-5.63
287	7	17	-59	-8.4				0.87	-0.6	-5.42
288	7	18	-60	-8.2				0.27	-0.5	-5.52
289	7	19	-59	-8.3				0.13	-0.42	-5.38
290	7	20	-59	-8.4				-0.15	-0.38	-5.3
291	7	21	-59	-7.9				0.15	-0.23	-5
292	7	22	-60	-8.4				0.29	0.11	-5.37
293	7	23	-50	-7.2				0.49	-0.62	-5.41
294	7	24	-47	-7.0				0.26	-0.79	-5.56
295	7	25	-66	-8.3				0.37	-0.9	-5.53
296	7	26	-43	-7.4				0.31	-0.51	-6.23
297	7	27	-36	-6.2				0.87	-0.24	-6.15
298	7	28	-46	-6.9				-0.4	-0.86	-5.51
299	7	29	-57	-8.4				-0.01	-1.06	-5.83
300	7	30	-64	-8.0				0.67	-0.75	-5.43
301	7	31	-67	-8.4				-0.11	-0.53	-5.15
302	7	32	-47	-7.0				0.89	-0.33	-4.76
303	7	33	-51	-6.4				0.05	-0.31	-4.29
304	7	34	-38	-6.4				0.01	-0.87	-5.52
305	7	35	-48	-6.3				0.6	-1.09	-5.72
306	7	36	-66	-8.6				0.25	-0.33	-4.35
307	7	37	-68	-8.9				0.48	-0.54	-4.48
308	7	38	-67	-8.8				0.33	-0.55	-4.49
309	7	39	-73	-8.6				-0.08	-0.69	-4.95
310	7	40	-71	-9.2				0.29	-0.37	-4.94

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
311	7	41	-61	-7.9				1.11	-1.02	-5.39
312	7	42	-64	-8.4				0.47	-0.34	-4.3
313	7	43	-70	-8.8				-0.14	-0.11	-4.66
314	7	44	-47	-6.8				0.8	-0.57	-5.06
315	7	45	-39	-6.7				0.18	-1.1	-5.95
316	7	46	-41	-6.7				0.62	-0.65	-5.84
317	7	47	-52	-6.9				-0.43	-0.41	-5.36
318	7	48	-54	-7.6				0.94	-0.6	-5.75
319	7	49	-59	-8.3				0.51	-0.36	-5.17
320	7	50		-57.4				-1.83	-1.66	-4.7
321	7	51	-55	-6.9				0.76	-0.34	-5.2
322	7	52	-63	-7.8				0.32	-0.21	-4.88
323	7	53	-61	-7.2				0.62	-0.31	-5.11
324	7	54	-61	-8.3				0.34	-0.45	-5.36
325	7	55	-63	-8.3				0.58	-0.29	-4.95
326	7	56	-61	-8.3				0.43	-0.3	-5.16
327	8	1						0.75	-0.23	-5.29
328	8	2						0.6	-0.25	-5.7
329	8	3						0.61	-0.26	-5.29
330	8	4						0.41	-0.25	-5.7
331	8	5						1.55	-0.31	-5.41
332	8	6						0.83	-0.33	-5.48
333	8	7						0.66	-0.38	-5.59
334	8	8						0.52	-0.62	-5.45
335	8	9						0.61	-0.59	-5.42
336	8	10						0.74	-0.33	-5.07
337	8	11						0.99	-0.62	-5.43
338	8	12						0.8	-0.58	-5.38
339	8	13						0.34	-0.73	-5.38
340	8	14						0.3	-0.61	-5.39
341	8	15						0.47	-0.53	-5.37
342	8	16						0.53	-0.55	-5.38
343	8	17						0.41	-0.58	-5.5
344	8	18						0.48	-0.71	-5.63
345	8	19						0.89	-0.51	-4.76

Master #	Ref. #	Well Ref. #	δ^{2}H	δ^{18}O	^{14}C	δ^{13}C	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
346	8	20						1.16	-0.57	-5.07
347	8	21						0.55	-0.27	-5.36
348	8	22						0.52	-0.39	-5.4
349	9	1	-47	-4.9	77.6			0.33	-0.13	-4.56
350	9	2	-49	-4.8	85.5			0.19	0.09	-5.24
351	9	3	-44	-3.9	72.1			-0.02	0.07	-5.07
352	9	4	-41	-3.2	83			0.38	0.12	-4.55
353	9	5	-43	-3.6	99.4			0.35	0.05	-4.58
354	9	6	-42	-3.5	100			0.31	0.04	-4.83
355	9	7	-43	-3.6	93.9			0.22	-0.22	-4.21
356	9	8	-45	-4.4	87.5			0.17	-0.03	-4.41
357	9	9	-49	-5.3	4.4	0.7		-0.26	-0.54	-5.27
358	9	10	-47	-4.8	3.2	0.7		-0.3	-0.53	-5.29
359	9	11	-48	-4.8	7.9			0.16	-0.52	-5.15
360	9	12	-47	-4.6	5.8			0.02	-0.73	-5.25
361	9	13	-49	-5.0	1.75	0.7		0.12	-0.39	-5.38
362	9	14	-45	-4.0	8.8			-0.03	-0.42	-5.35
363	9	15	-45	-4.2	2.4	0.7		-0.03	-0.42	-5.35
364	9	16	-54	-6.1	10.4	0.9		0.17	-0.03	-5.65
365	9	17	-45	-4.1	6.1			-0.49	-0.7	-5.5
366	9	18	-52	-5.7	17.8	0.7		-0.29	-0.79	-5.74
367	9	19	-50	-5.4	28.5			-0.15	-0.27	-5.45
368	9	20	-44	-3.9	18.3	0.7		-0.41	-0.87	-5.41
369	9	21	-46	-4.8	11.9	0.7		-0.41	-0.88	-5.51
370	9	22	-52	-6.0	12			-0.1	-0.49	-4.53
371	9	23	-52	-5.6	6.3	0.8		-0.49	-1.09	-6.06
372	9	24	-47	-4.5	9.6	0.9		-0.44	-0.96	-5.64
373	9	25	-47	-5.0	27.8	0.7		-0.07	-0.37	-5.1
374	9	26	-49	-5.4	11.6	0.8		-0.31	-0.78	-5.59
375	9	27	-50	-6.1	-	0.7		0.08	-0.31	-4.82
376	9	28	-51	-5.2	11.6	-		-0.23	-0.69	-5.59
377	9	29	-47	-5.1	21.1	-		-0.45	-1.07	-5.91
378	9	30	-46	-6.0	10.8	-		-0.37	-1.02	-5.82
379	9	31	-50	-5.7		-		-0.43	-0.73	-4.87
380	10	1	-49	-5.4				-0.36	-0.22	-4.95

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
381	10	2	-38	-2.7				-0.34	0.18	-4.57
382	10	3	-48	-4.4				-0.24	-0.11	-4.88
383	10	4	-48	-5.0				0	-0.13	-4.45
384	10	5	-49	-5.1				-0.68	-0.49	-5.25
385	10	6	-46	-4.0				0.05	0.12	-4.33
386	10	7	-48	-4.9				0.01	0.05	-4.64
387	10	8	-47	-4.6				0.96	-0.01	-5.13
388	10	9	-43	-3.7				0.97	0.04	-4.95
389	10	10	-47	-4.6				0.44	-0.16	-4.43
390	10	11	-47	-4.6				0.96	-0.08	-4.45
391	10	12	-49	-5.1				-0.09	0.05	-4.34
392	10	13	-46	-4.2				-0.06	-0.1	-5.04
393	10	14	-47	-4.6				-0.24	-0.07	-5.31
394	10	15	-47	-4.5				0.09	-0.1	-5.3
395	10	16	-48	-5.0				-0.07	0.04	-4.85
396	10	17	-48	-5.1				-0.1	0	-5.19
397	10	18	-42	-3.5				0.52	-0.08	-5.39
398	10	19	-	-				-0.08	-0.13	-5.24
399	10	20	-44	-3.8				0.05	-0.15	-4.48
400	10	21	-46	-4.6				-0.45	-0.06	-5.44
401	10	22	-44	-4.2				-0.37	-0.03	-4.5
402	10	23	-45	-4.5				0.09	0.05	-5.02
403	11	1	-47	-6.8	6.3	-7.3		-0.5	-0.45	-5.72
404	11	2	-47	-6.6	34.5	-8.4		0.08	-0.3	-5.36
405	11	3	-48	-7.2	7.3	-5.4		0.14	-0.13	-4.92
406	11	4	-30	-4.5	24.2	-6.2		-0.19	-0.01	-4.29
407	11	5	-38	-5.5	40.5	-6.9		-0.16	-0.28	-5.89
408	11	6	-37	-4.6	44.9	-6.1		-0.05	-0.01	-4.35
409	11	7	-47	-5.9	6.7	-6.7		-0.19	-0.2	-4.32
410	11	8	-52	-7.0	13	-8.2		-0.09	-0.2	-4.94
411	11	9	-49	-6.6	12	-6.3		-0.36	-0.59	-4.83
412	11	10	-45	-5.8	6.4	-6.6		-0.11	0.02	-4.68
413	11	11	-51	-7.3	17.5	-7.5		0	0.03	-4.65
414	11	12	-46	-6.6	14.1	-6		-0.03	-0.3	-5.02
415	11	13	-44	-5.9	11.2	-8.1		-0.02	0.11	-4.16

Master #	Ref. #	Well Ref. #	δ^{2}H	δ^{18}O	^{14}C	δ^{13}C	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
416	11	14	-38	-5.2	15.2	-8.4		-0.28	-0.39	-5.24
417	11	15	-56	-5.8	17.1	-7.6		-0.01	-0.46	-4.83
418	11	16	-60	-8.1	6.8	-7.2		0.18	-0.18	-5.2
419	11	17	-57	-7.6	7.5	-6.4		-0.32	-0.39	-5.15
420	11	18	-58	-7.8	7.3	-6.4		-0.2	-0.26	-5.04
421	11	19	-52	-6.5	8.4	-8.2		-0.24	-0.25	-4.78
422	11	20	-53	-7.0	8.7	-11.2		0.05	-0.17	-4.74
423	11	21	-51	-7.3	9.2	-8.6		-0.09	-0.2	-4.75
424	11	22	-58	-8.0	6.8	-6.5		0.01	-0.27	-5.2
425	11	23	-51	-6.9	10.1	-8.3		-0.46	-0.26	-4.49
426	11	24	-39	-6.2	36.2	-7.2		-0.18	-0.11	-5.19
427	11	25	-51	-7.7	18	-7.5		0.12	-0.06	-5.11
428	11	26	-41	-6.2	24.9	-6.8		-0.22	0.02	-4.81
429	11	27	-49	-6.7	11.9	-7.2		0.04	-0.19	-4.44
430	11	28	-49	-7.1	6.5	-6.4		-0.17	-0.18	-4.41
431	12	1	-47	-6.0					-0.71	-5.24
432	12	2	-52	-6.2					-0.88	-5.54
433	12	3	-53	-6.1					-0.77	-5.48
434	12	4	-	-					-0.16	-4.95
435	12	5	-	-					-0.93	-5.59
436	12	6	-45	-6.3					-0.2	-4.67
437	12	7	-	-					-0.4	-4.55
438	12	8	-51	-6.0					-0.21	-4.64
439	12	9	-53	-6.5					-0.17	-5.01
440	12	10	-46	-5.5					-0.26	-4.14
441	12	11	-50	-6.1					-0.33	-5.01
442	12	12	-	-					-0.9	-5.57
443	12	13	-49	-6.0					-0.71	-5.46
444	12	14	-51	-6.2					-0.75	-5.37
445	12	15	-	-					-0.8	-5.43
446	12	16	-50	-6.0					-0.79	-5.42
447	12	17	-	-					-0.35	-4.9
448	12	18	-50	-6.0					-0.56	-5.32
449	12	19	-	-					-0.84	-5.48
450	12	20	-50	-6.0					-0.73	-5.4

Master #	Ref. #	Well Ref. #	δ²H	δ¹⁸O	¹⁴C	δ¹³C	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
451	12	21	-	-					-0.88	-5.52
452	12	22	-49	-6.7					-0.15	-4.99
453	12	23	-50	-5.7					-0.99	-5.67
454	12	24	-	-					-2.12	-5.81
455	12	25	-53	-5.9					-0.85	-5.47
456	12	26	-49	-5.9					-0.74	-5.38
457	12	27	-52	-6.7					-0.46	-5
458	12	28	-55	-6.4					-0.36	-5.11
459	12	29	-	-					-0.59	-5.21
460	12	30	-52	-6.1					-0.77	-5.49
461	12	42	-81	-8.6					-0.57	-5
462	12	43	-64	-8.3					0.09	-4.3
463	12	44	-55	-7.7					-0.11	-4.36
464	13	1	-52	-4.0				0.5	-1.31	-5.88
465	13	2	-58	-6.4				-0.09	-1.1	-5.03
466	13	3	-58	-7.0				-0.19	-0.94	-5.19
467	13	4	-57	-6.7				-0.27	-1.1	-5.43
468	13	5	-59	-7.1				-0.13	-1.01	-5.52
469	13	6	-62	-7.1				-0.1	-0.94	-5.6
470	13	7	-63	-7.9				0.69	-1.03	-5.71
471	13	8	-62	-7.2				0.05	-1.05	-5.61
472	13	9	-64	-8.0				0.09	-0.97	-5.59
473	13	10	-58	-7.2				-0.13	-1.11	-5.25
474	13	11	-64	-7.8				0.2	-0.88	-5.42
475	13	12	-51	-5.2				0.29	-0.1	-3.77
476	13	13	-65	-7.8				-0.03	-0.81	-5.39
477	13	14	-60	-6.9				0.34	-0.79	-5.11
478	13	15	-58	-6.9				0.09	-0.95	-5.1
479	13	16	-52	-5.1				0.01	-1.18	-5.86
480	13	17	-51	-4.5				-0.07	-1.55	-6.21
481	13	18	-54	-5.2				0.09	-1.47	-6.03
482	13	19	-58	-6.5				0.09	-1.25	-5.6
483	13	20	-60	-6.7				0.13	-1.11	-5.78
484	13	21	-57	-6.3				-0.22	-1.05	-5.55
485	13	22	-60	-7.4				0.07	-0.88	-5.11

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
486	13	23	-57	-7.2				0.06	-1.15	-5.73
487	13	24	-58	-7.4				0.33	-1.21	-5.63
488	13	25	-59	-6.5				0.19	-0.95	-5.29
489	13	26	-50	-4.7				-0.02	-1.97	-6.66
490	13	27	-59	-7.1				0	-2.45	-7.94
491	13	28	-56	-6.8				0.01	-1.61	-6.91
492	13	29	-50	-4.9				0.94	-1.41	-6.83
493	13	30	-51	-5.3				0.18	-1.9	-7.1
494	13	31	-59	-6.3				0.2	-1.04	-5.4
495	13	32	-65	-7.8				0.21	-0.34	-4.72
496	13	33	-61	-6.6				0.16	-0.67	-5.14
497	13	34	-52	-4.0				0.03	-1.47	-5.99
498	13	35	-58	-6.4				0.21	-0.91	-5.6
499	13	36	-58	-7.0				0.36	-1.13	-5.23
500	13	37	-57	-6.7				0.24	-1.53	-5.94
501	13	38	-59	-7.1				0.02	-0.7	-5.67
502	13	39	-62	-7.1				0.02	-1.24	-6.3
503	13	40	-63	-7.9				-0.05	-1.32	-6.98
504	13	41	-62	-7.2				0.12	-0.82	-4.93
505	13	42	-64	-8.0				0.06	-1.19	-5.42
506	13	43	-58	-7.2				0.41	-0.57	-4.64
507	13	44	-64	-7.8				0.1	-0.85	-5.89
508	13	45	-51	-5.2				0.1	-1.18	-5.83
509	13	46	-65	-7.8				0.1	-1.42	-5.95
510	13	47	-60	-6.9				0.08	-1.52	-6.23
511	13	48	-58	-6.9				0.17	-1.12	-5.4
512	13	49	-52	-5.1				0.22	-0.77	-5.33
513	13	50	-51	-4.5				0.11	-1.54	-6.17
514	13	51	-54	-5.2				0.36	-0.69	-5.55
515	13	52	-58	-6.5				0.21	-1.3	-6.1
516	13	53	-60	-6.7				-1.07	-1.33	-5.16
517	13	54	-52	-4.0				0.34	-0.42	-5.23
518	13	55	-62	-7.9				-0.08	-0.99	-5.95
519	13	56	-56	-6.4				-0.07	-1.14	-6.2
520	13	57	-60	-7.8				0.02	-1.3	-6.32

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
521	13	58	-59	-6.8				-0.01	-1.26	-6.33
522	13	59	-51	-5.7				-0.59	-1.16	-6.4
523	13	60	-62	-8.5				-0.35	-1.77	-7.72
524	13	61	-56	-7.2				-0.26	-0.75	-5.63
525	13	62	-43	-6.2				-0.1	-0.1	-6.94
526	13	63	-54	-6.9				-0.19	-1.3	-7.05
527	13	64	-55	-7.2				-0.12	-0.71	-6.44
528	13	65	-57	-7.2				-0.33	-0.84	-6.61
529	13	66	-51	-6.9				-0.13	-1.16	-7.39
530	13	67	-54	-7.3				-0.11	-1.02	-6.5
531	13	68	-49	-6.5				-0.13	-0.72	-6.57
532	13	69	-49	-7.0				-0.04	-0.39	-5.11
533	13	70	-40	-4.5				-0.21	-0.79	-5.11
534	13	71	-46	-6.0				-0.06	-0.87	-5.14
535	13	72	-54	-7.4				-0.4	-2.11	-8.45
536	13	73	-41	-6.0				-0.31	-0.67	-6.07
537	13	74	-40	-6.0				0.4	-0.46	-5.85
538	13	75	-52	-6.7				0.01	-0.51	-5.77
539	13	76	-44	-5.5				-0.43	-0.43	-5.94
540	13	77	-58	-7.6				-0.37	-0.94	-5.95
541	13	78	-35	-4.7				-0.03	-1.62	-7.42
542	13	79	-60	-7.9				0.13	-1.09	-5.86
543	13	80	-58	-6.7				0.06	-1.04	-6
544	13	81	-57	-7.9				0.01	-1.19	-6.54
545	13	82	-51	-7.7				-0.05	-1.45	-7
546	13	83	-45	-4.1					-1.8	-7.36
547	13	84	-46	-4.4					-2.08	-6.92
548	13	85	-46	-4.6					-2.16	-6.32
549	13	86	-46	-4.6					-2.4	-6.48
550	13	87	-67	-9.1					-1.27	-5.74
551	13	88	-67	-8.7					-1.04	-5.23
552	13	89	-59	-7.5					-1.98	-7.19
553	13	90	-35	-2.2					-2.09	-7
554	13	91	-43	-3.9					-2.07	-7.06
555	13	92	-43	-4.0					-2.44	-7.39

Master #	Ref. #	Well Ref. #	δ2H	δ18O	14C	δ13C	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
556	13	93	-42	-4.1					-2.49	-7.21
557	13	94	-43	-4.4					-2.2	-7.42
558	13	95	-42	-4.0					-1.13	-4.93
559	13	96	-49	-5.2					-2.27	-7.66
560	13	97	-48	-4.5					-2.18	-7.54
561	13	98	-43	-3.3					-1.78	-6.16
562	13	99	-44	-3.7					-1.49	-6.47
563	13	100	-51	-5.8					-1.88	-6.97
564	13	101	-48	-4.3					-1.77	-6.58
565	13	102	-49	-4.6					-1.57	-7.01
566	13	103	-46	-4.0					-1.61	-6.8
567	13	104	-50	-4.9					-1.51	-6.84
568	13	105	-47	-4.3					-1.26	-6.37
569	13	106	-49	-4.5					-1.54	-6.79
570	13	107	-48	-4.4					-1.53	-6.6
571	13	108	-50	-4.5					-1.38	-6.07
572	13	109	-43	-2.6					-1.24	-5.67
573	13	110	-48	-4.5					-1.63	-6.04
574	13	111	-52	-5.0					-1.58	-5.96
575	14	1/1	-47	-4.6				0.4	0	-5.31
576	14	2/1	-46	-4.2				0.88	-0.04	-5.04
577	14	3/1	-46	-4.5				-0.31	0.12	-4.35
578	14	4/2	-44	-3.9				0.85	0.1	-5.12
579	14	5/2	-50	-5.3				0.6	-0.01	-5.38
580	14	6/2	-48	-5.1				0.64	0.08	-5.19
581	14	7/2						0.57	-0.03	-5.39
582	14	8/2	-49	-4.9				0.8	-0.01	-5.37
583	14	9/3	-44	-3.8				0.58	-0.09	-4.48
584	14	10/8	-46	-4.6				0.77	0.01	-5.43
585	14	11/9	-44	-4.2				1.14	0.05	-4.5
586	14	12/9	-45	-4.5				0.42	0.1	-5.02
587	14	13/5	-44	-5.1				1.06	0.07	-4.69
588	14	14/5	-43	-3.7				1.42	-0.05	-4.98
589	14	15/5	-43	-3.5				0.51	-0.22	-4.21
590	14	16/9	-47	-4.6				1.02	0.12	-4.91

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
591	14	17/9	-47	-4.6				0.38	0.05	-5.13
592	14	18/4	-42	-3.5				0.4	0.04	-4.84
593	14	19/9	-44	-3.7				0.42	0.1	-5.02
594	14	20/4						1.03	0.05	-4.58
595	14	21/2	-48	-4.8				0.81	0.1	-4.95
596	14	22/2	-49	-4.8				0.98	0.08	-5.25
597	14	23/2	-48	-4.3				0.58	-0.12	-4.43
598	14	24/4	-41	-3.2				0.37	0.12	-4.55
599	14	25/2	-48	-4.7				0.53	-0.03	-4.45
600	14	26/1						0.1	-0.03	-4.89
601	14	27/1	-49	-5.1				-0.31	0.12	-4.35
602	14	28/2	-40	-4.7				-0.41	0.05	-4.13
603	14	29/2	-47	-4.9				0.13	-0.13	-4.56
604	14	30/6 7	-45	-4.2				0.17	-0.03	-4.41
605	14	31/12	-49	-6.7				0.75	-0.01	-4.87
606	14	32/12	-37	-4.6				0.74	0.07	-4.29
607	14	33/12	-45	-5.8				1.19	-0.02	-4.63
608	14	34/12	-44	-5.9				0.72	0.16	-4.07
609	14	35/12	-47	-6.0				0.96	0.18	-4.25
610	14	36/11	-47	-6.6				0.47	-0.3	-5.36
611	14	37/10	-47	-6.8				0.63	-0.33	-5.54
612	14	38/11	-30	-4.5				0.97	-0.19	-5.19
613	14	39/7	-38	-5.2				0.29	-0.05	-4.53
614	14	40/12						0.67	-0.49	-5.91
615	14	41/12						-0.05	-0.05	-4.46
616	14	42/12						1.13	-0.04	-4.27
617	14	43/12						0.47	-0.08	-3.6
618	14	44/12						0.44	-0.03	-3.1
619	14	45/12						0.39	-0.02	-4.73
620	14	46/12						0.75	-0.01	-4.87
621	14	47/12						0.46	-0.05	-4.86
622	14	48/12						0.22	-0.06	-4.34
623	14	49/12						0.55	-0.06	-4.19
624	14	50/12						0.13	-0.03	-4.03
625	14	51/12						0.69	-0.2	-4.94

Master #	Ref. #	Well Ref. #	δ^2H	$\delta^{18}O$	^{14}C	$\delta^{13}C$	87Sr/86Sr	Calcite SI	Gypsum SI	Halite SI
			‰ VSMOW	‰ VSMOW	p.m.c.	‰ PDB				
626	14	52/12						0.76	-0.05	-4.34
627	14	53/12						0.56	-0.09	-3.61
628	14	54/12						0.62	-0.07	-3.71
629	14	55/12						0.43	-0.04	-4.58
630	14	56/12						0.54	0.1	-4.45
631	14	57/12						0.66	0.13	-3.85
632	14	58/12						0.21	-0.03	-3.96
633	14	59/12						0.45	-0.06	-4.16
634	14	60/12						0.72	0.1	-4.36
635	14	61/12						0.96	0.18	-4.25
636	14	62/12						0.74	0.07	-4.29
637	14	63/12						0.53	0.02	-4.21
638	14	64/12						1.24	-0.02	-4.69
639	14	65/12						0.54	-0.06	-4.13
640	14	66/12						0.8	-0.11	-4.26
641	14	67/12						0.35	-0.08	-4.18
642	14	68/12						0.54	-0.07	-4.64
643	14	69/12						0.43	-0.05	-4.36
644	14	70/12						1.19	-0.02	-4.63
645	14	71/12						0.79	0.1	-4.27
646	14	72/12						1.01	-0.04	-4.12
647	14	73/12						0.96	-0.07	-4.36
648	14	74/12						0.91	-0.07	-4.45
649	14	75/12						0.93	-0.04	-4.26
650	14	76/11						0.9	-0.09	-5.96
651	14	77/11						0.8	-0.09	-5.23
652	14	78/11						0.84	-0.06	-5.87
653	14	79/10						0.72	0.16	-4.07
654	14	80/10						0.43	-0.01	-5.22
655	14	81/10						-1.13	-0.04	-4.82
656	14	82/10						1.1	0.2	-3.32
657	14	83/10						0.45	-0.14	-5.4
658	14	84/10						0.43	-0.04	-5.18
659	14	85/10						0.36	0	-4.87

Supplementary Figures- Appendix C

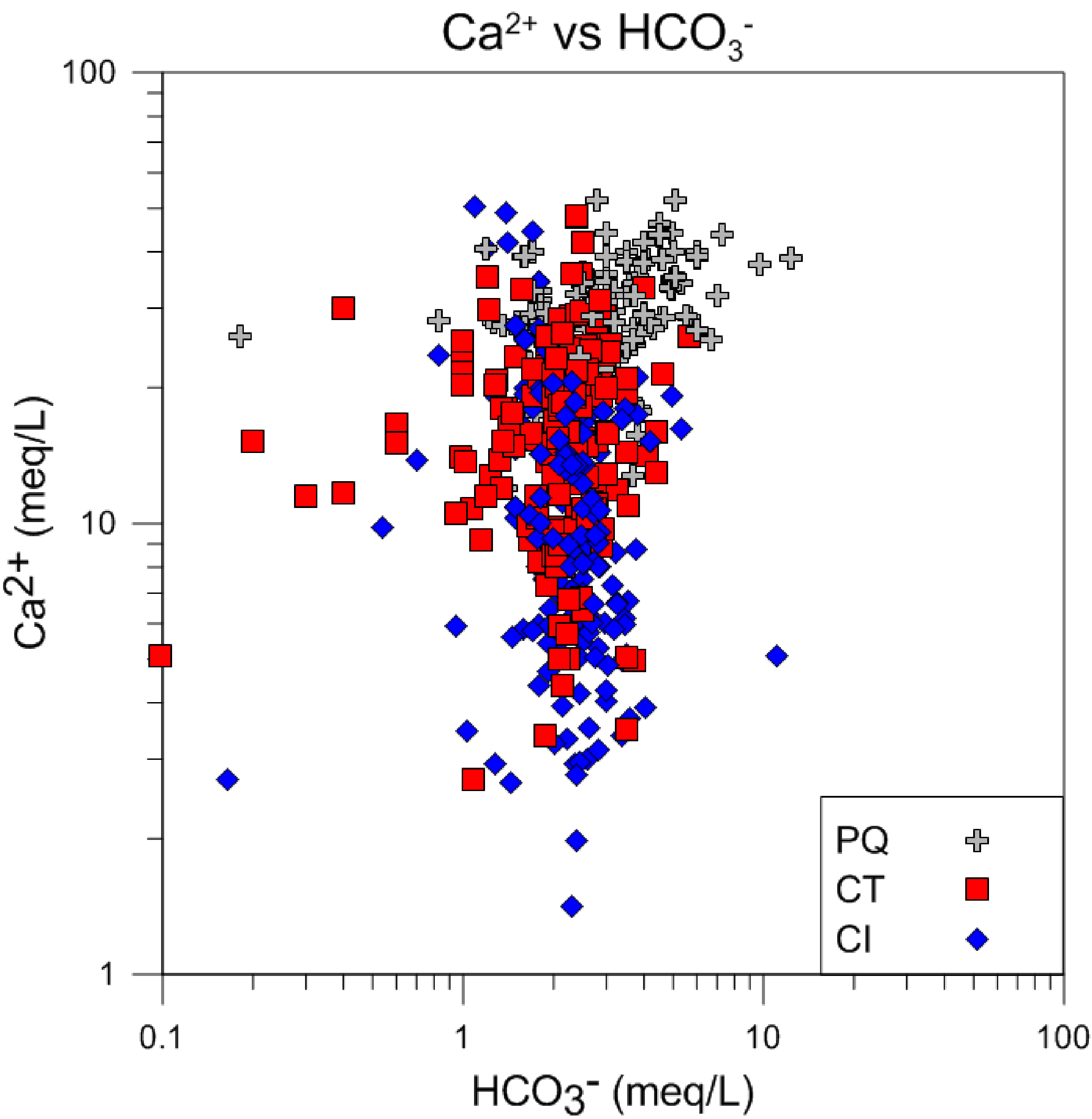


Fig. 13 Relationship between Ca^{2+} and HCO_3^-

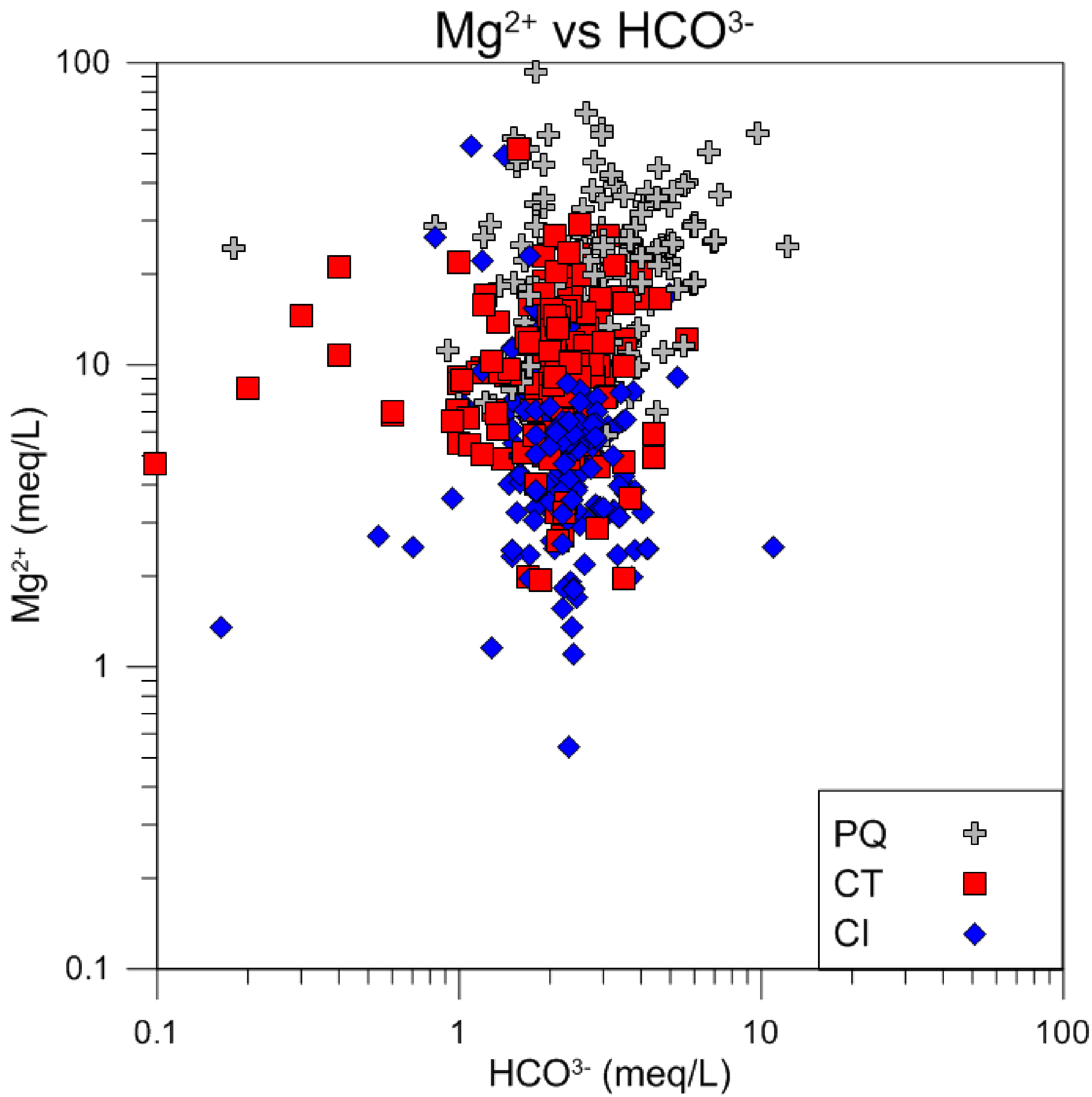


Fig. 14 Relationship between Mg^{2+} and HCO_3^-

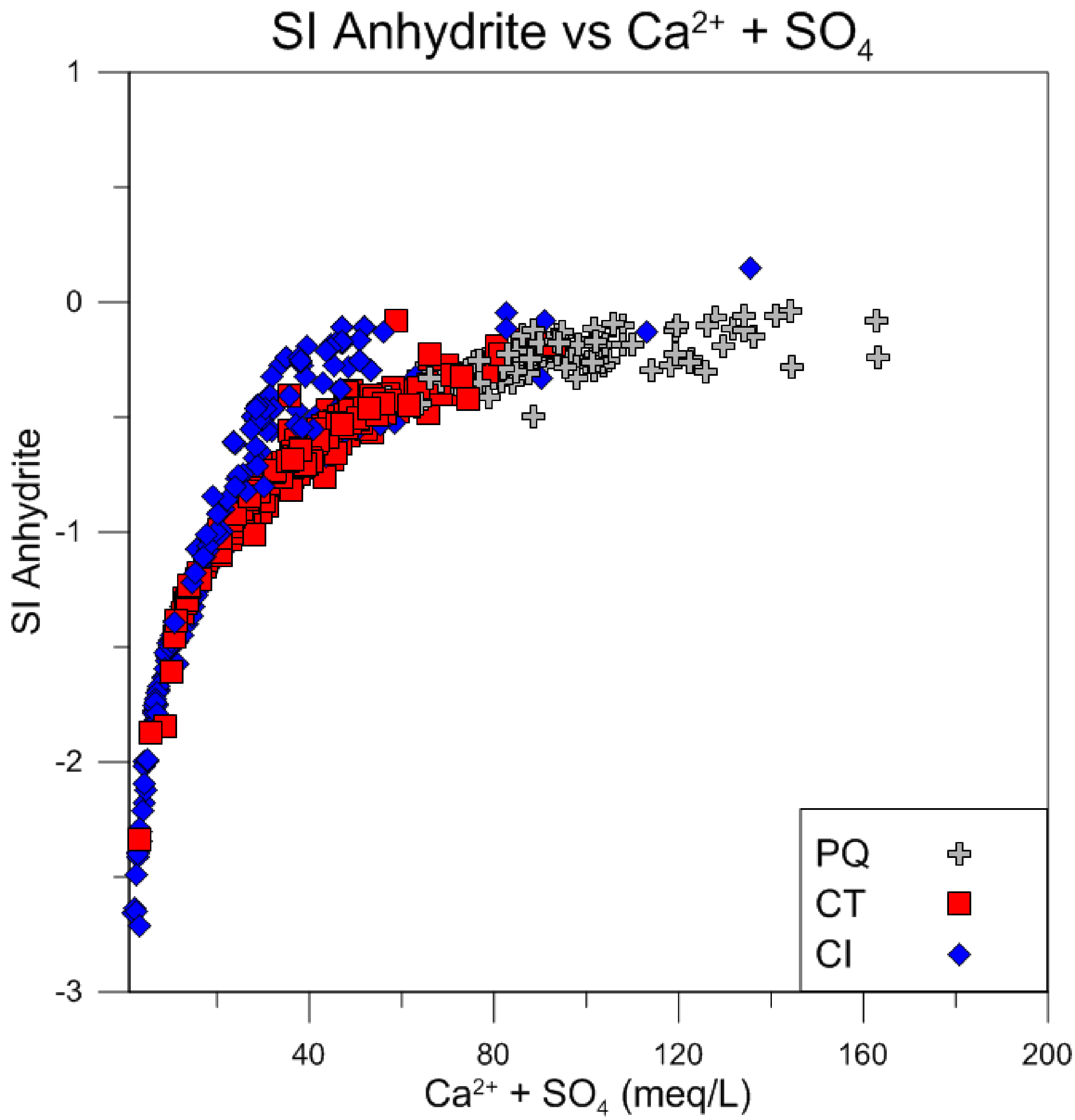


Fig. 15 Relationship between saturation indices of anhydrite and Ca^{2+}+SO_4

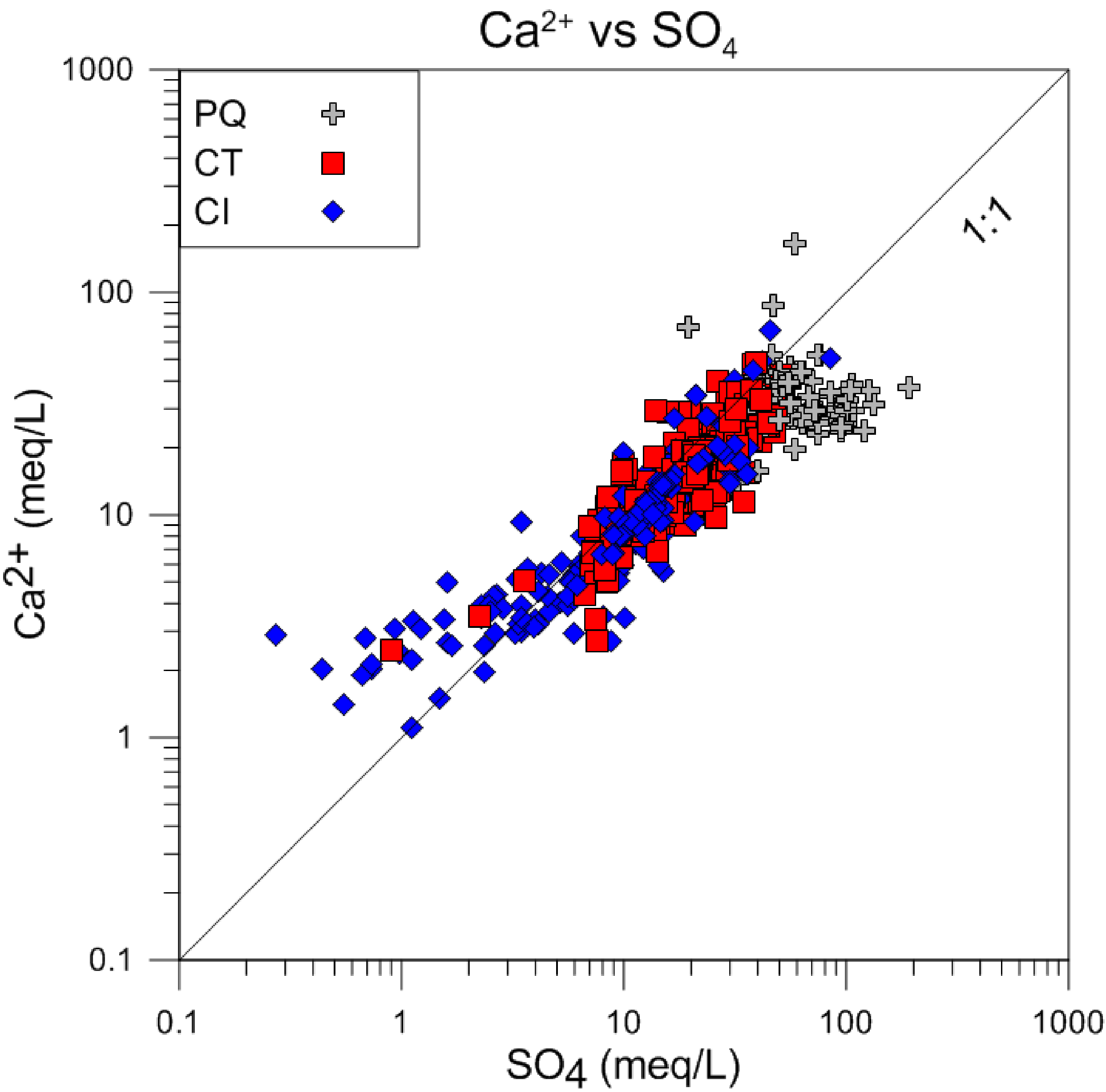


Fig. 16 Relationship between Ca^{2+} and SO_4

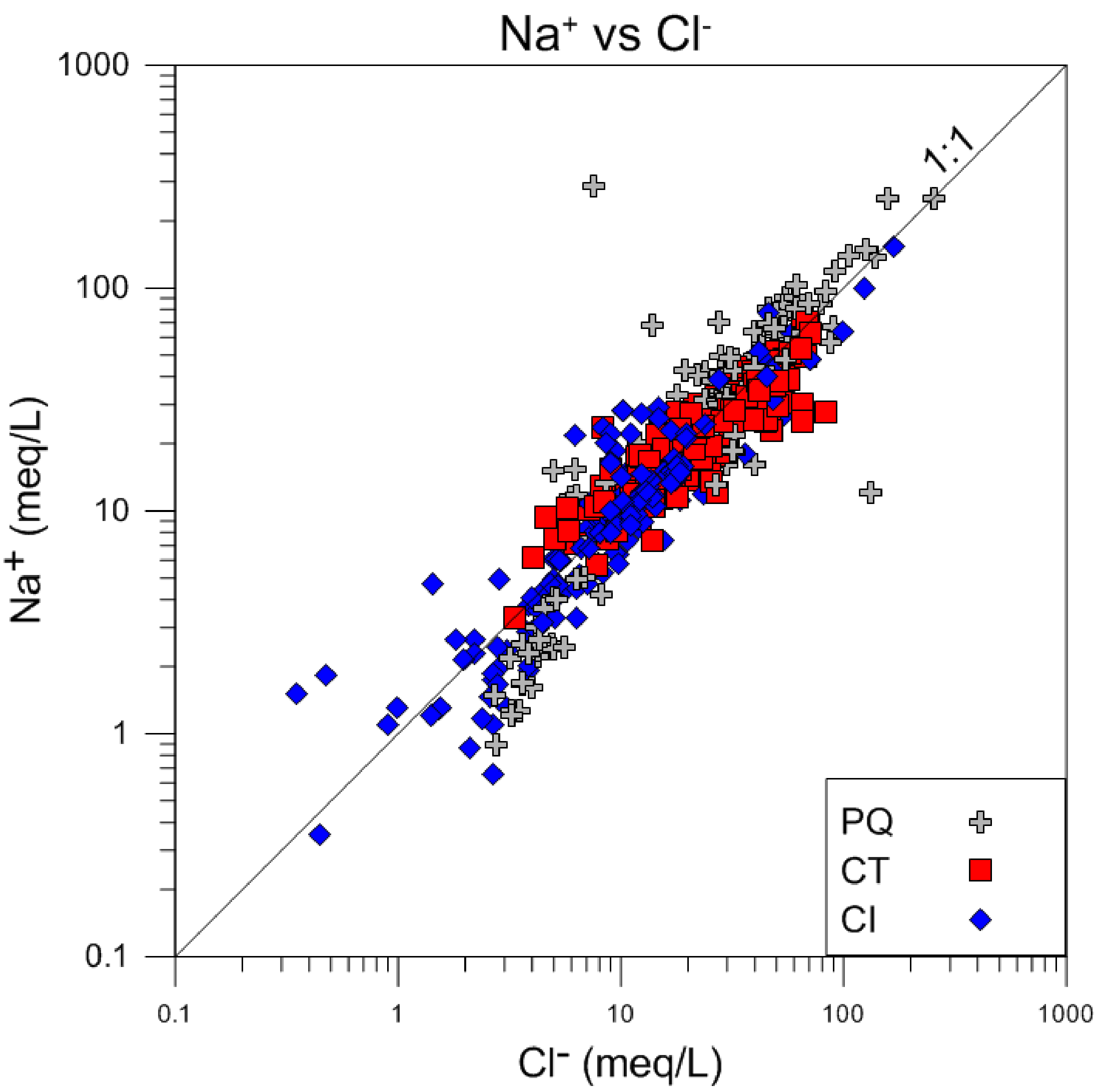


Fig. 17 Relationship between Na^{+} and Cl^{-}

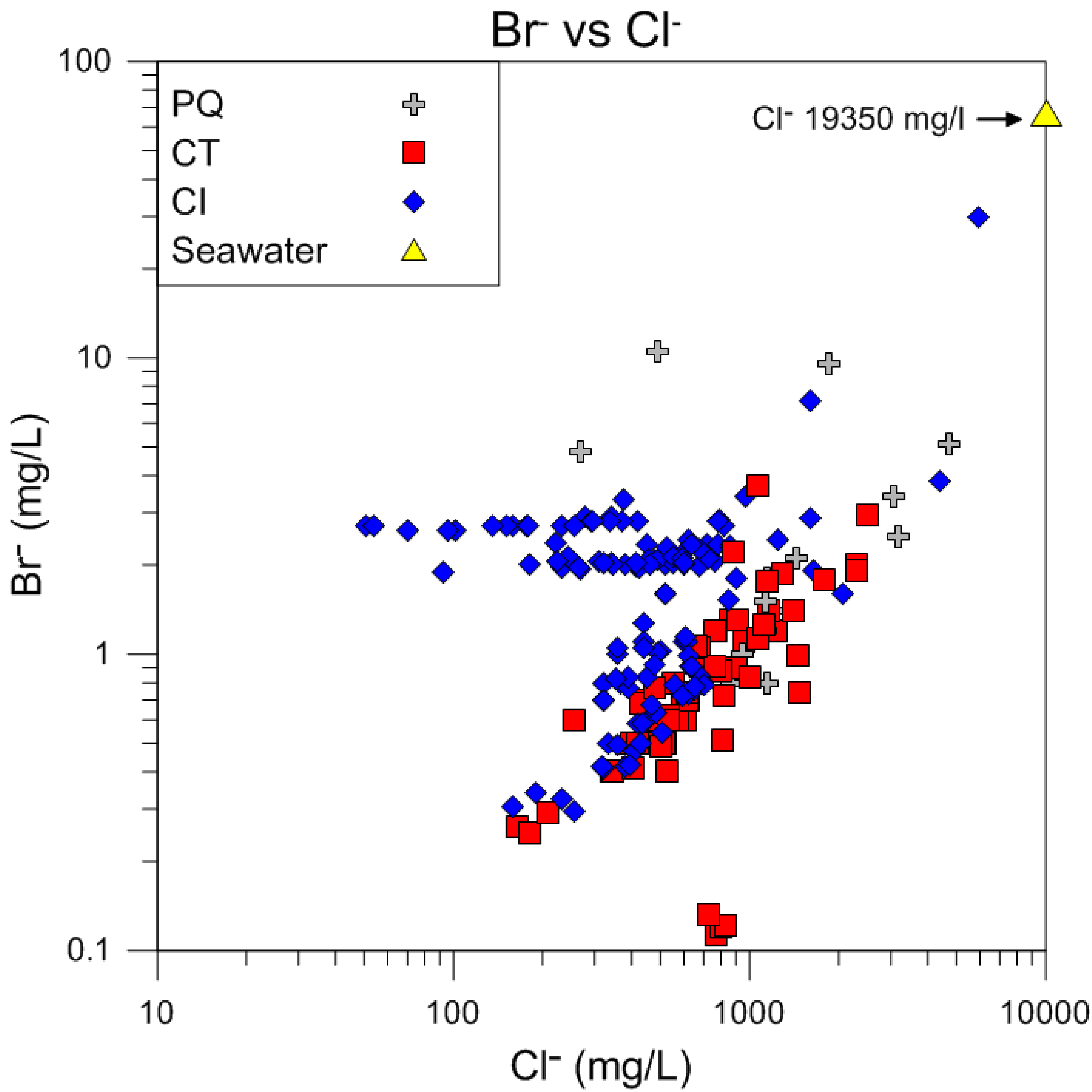


Fig. 18 Relationship between Br^- and Cl^-

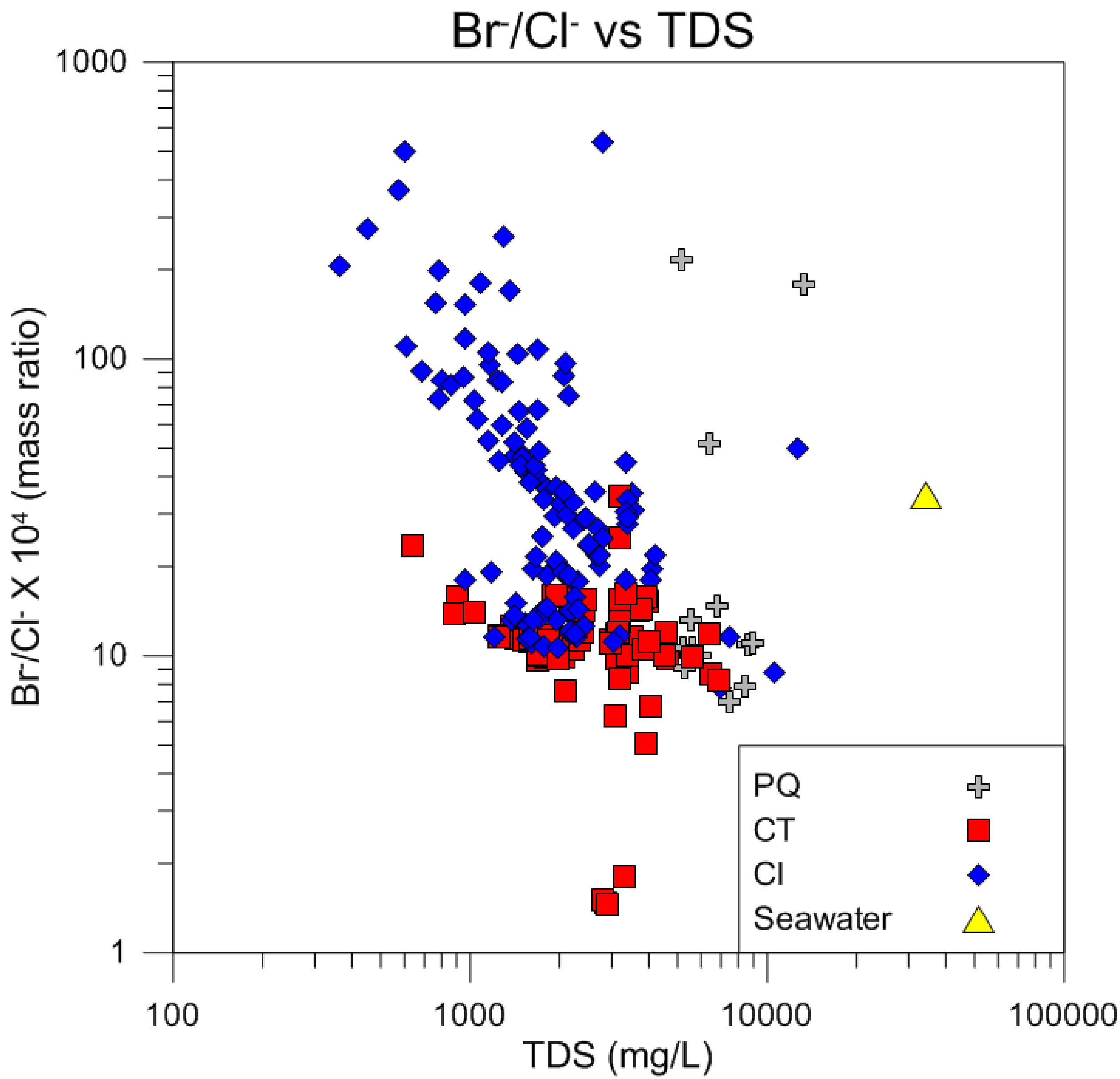


Fig. 19 Relationship between Br^{-}/Cl^{-} X 10^4 and total dissolved solids

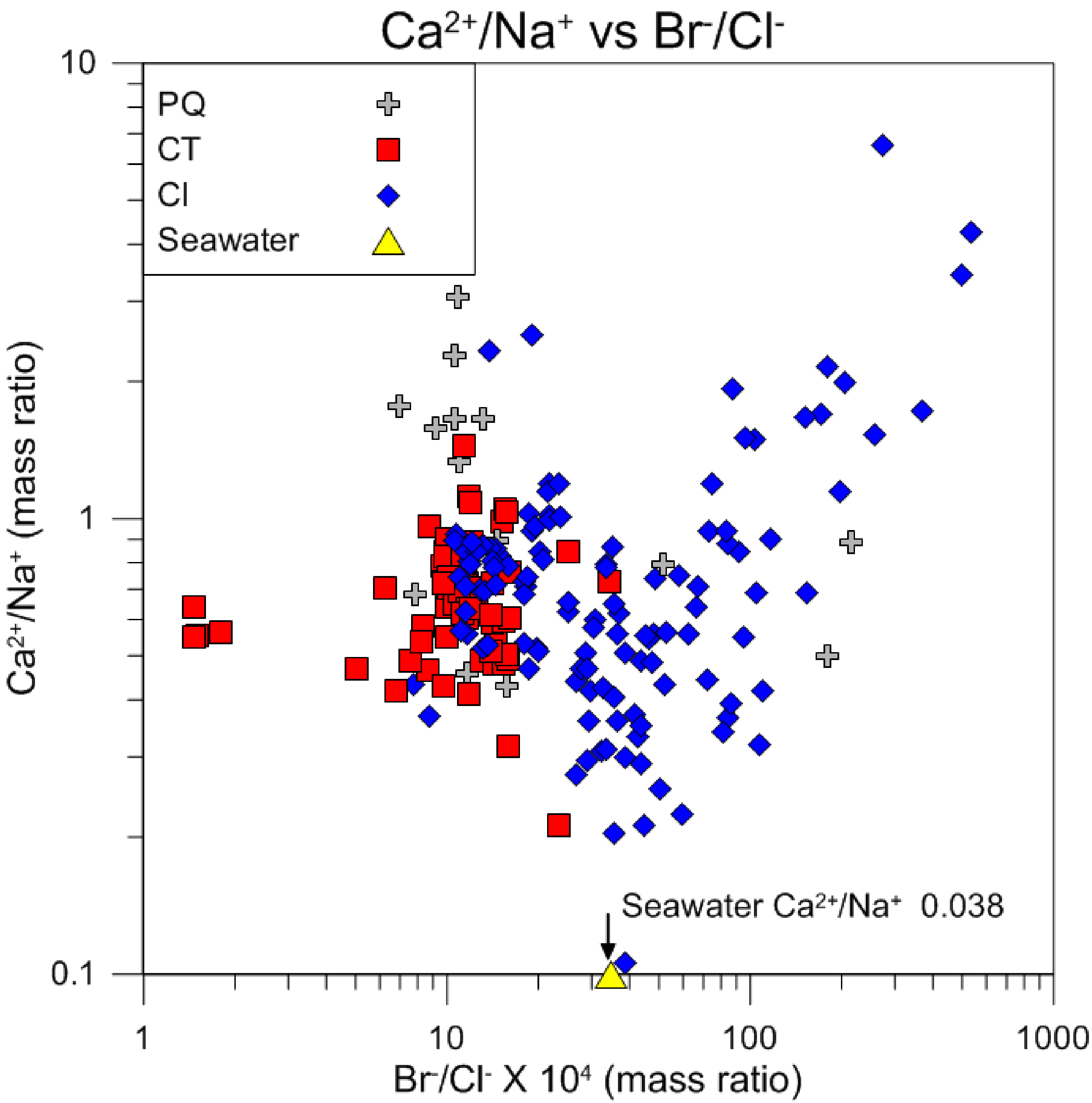


Fig. 20 Relationship between Ca^{+}/Na^{+} and Br^{-}/Cl^{-} X 10^{4}

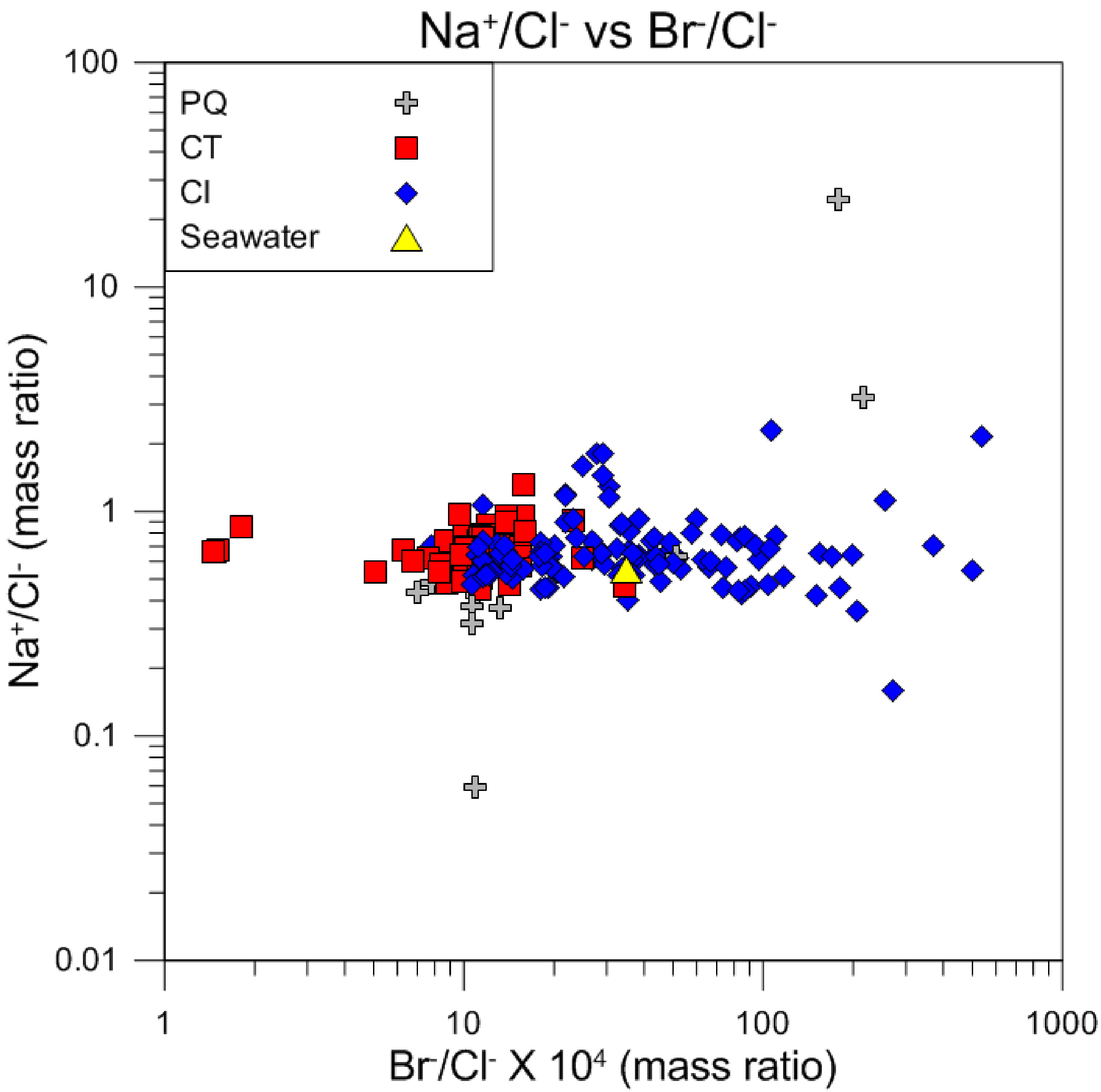


Fig. 21 Relationship between Na^+/Cl^- and Br^-/Cl^- X 10^4

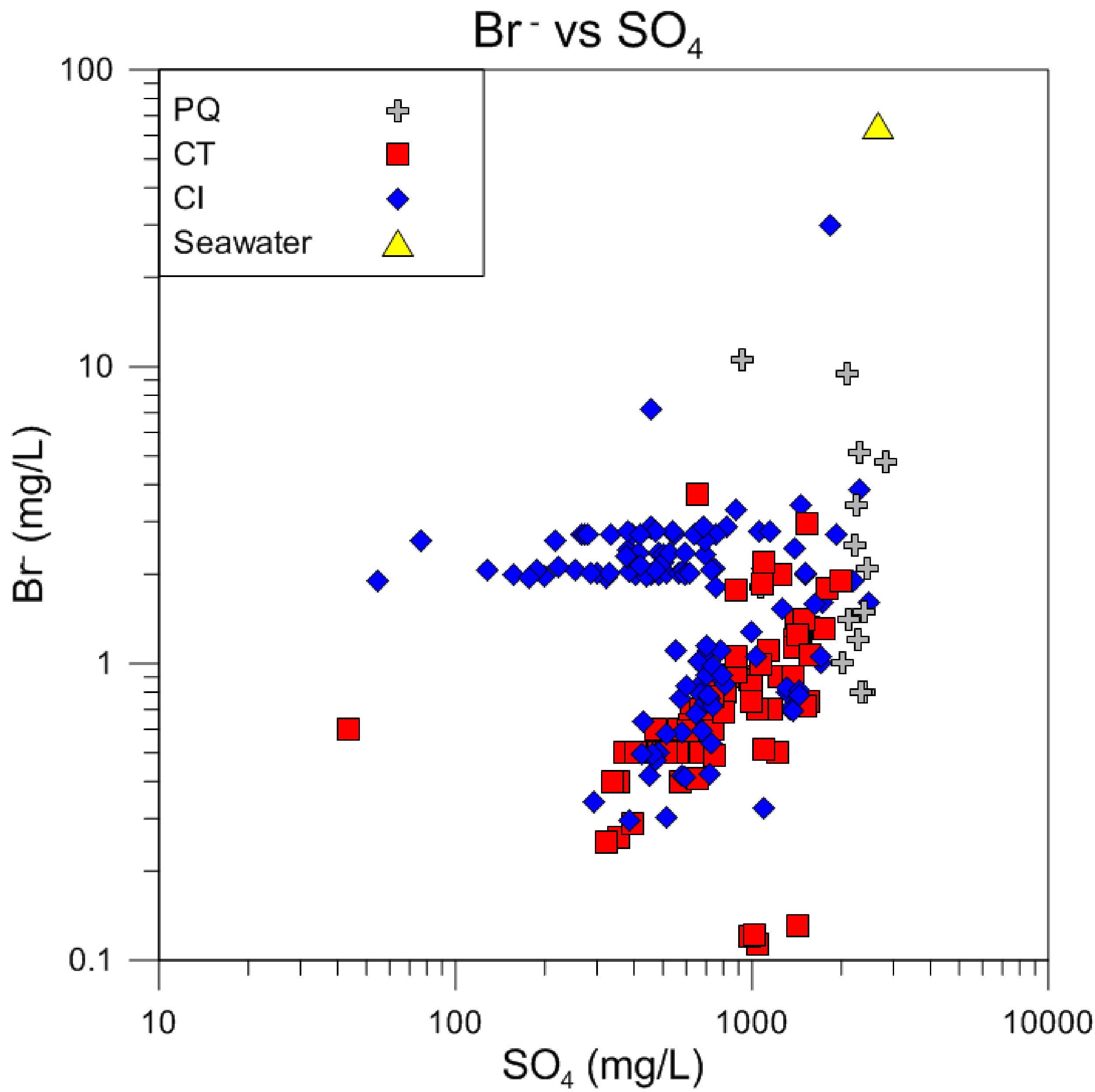


Fig. 22 Relationship between Br^- and SO_4

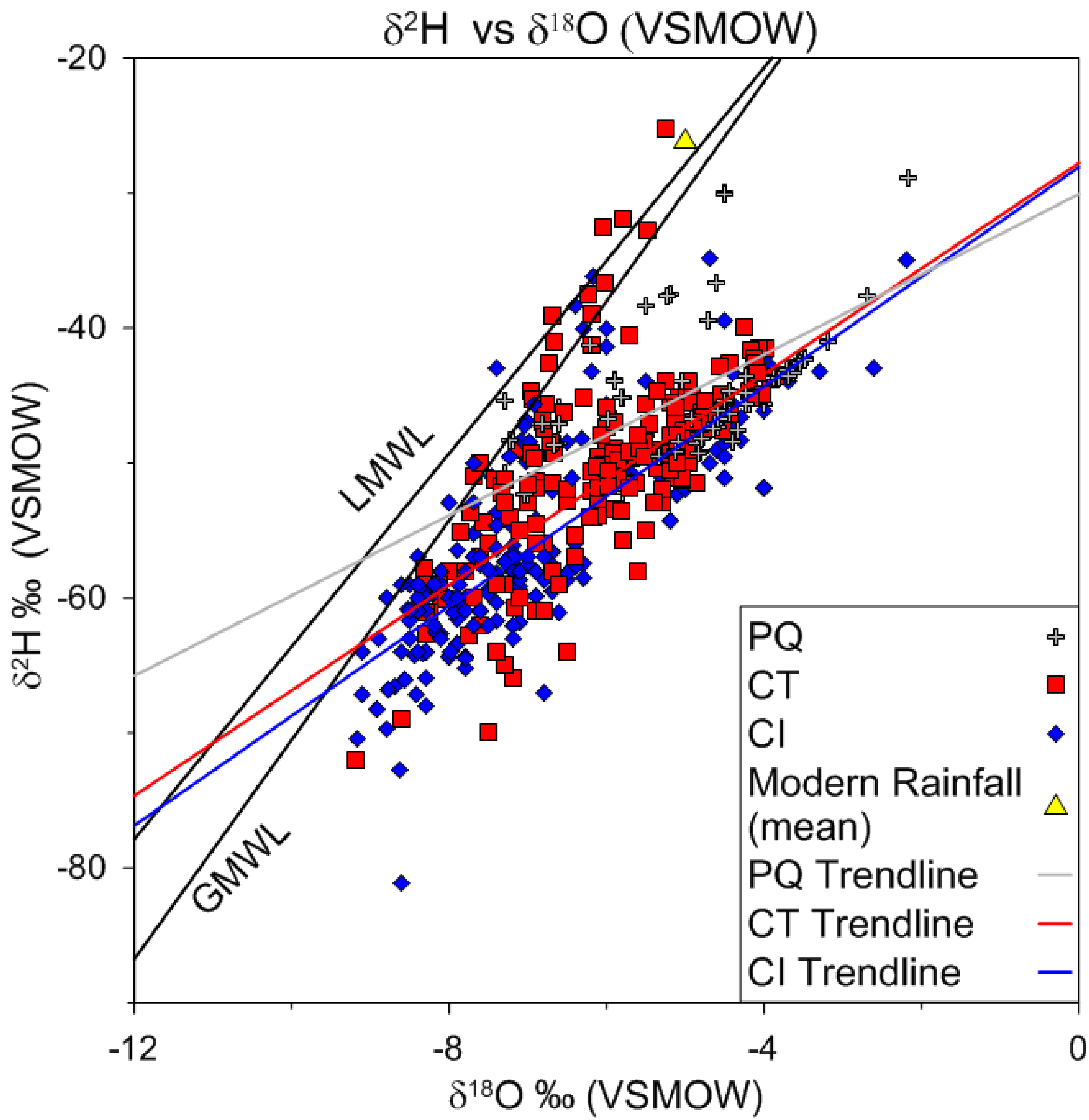


Fig. 23 δ^2H vs $\delta^{18}O$ plot (VSMOW) with trend lines for each aquifer

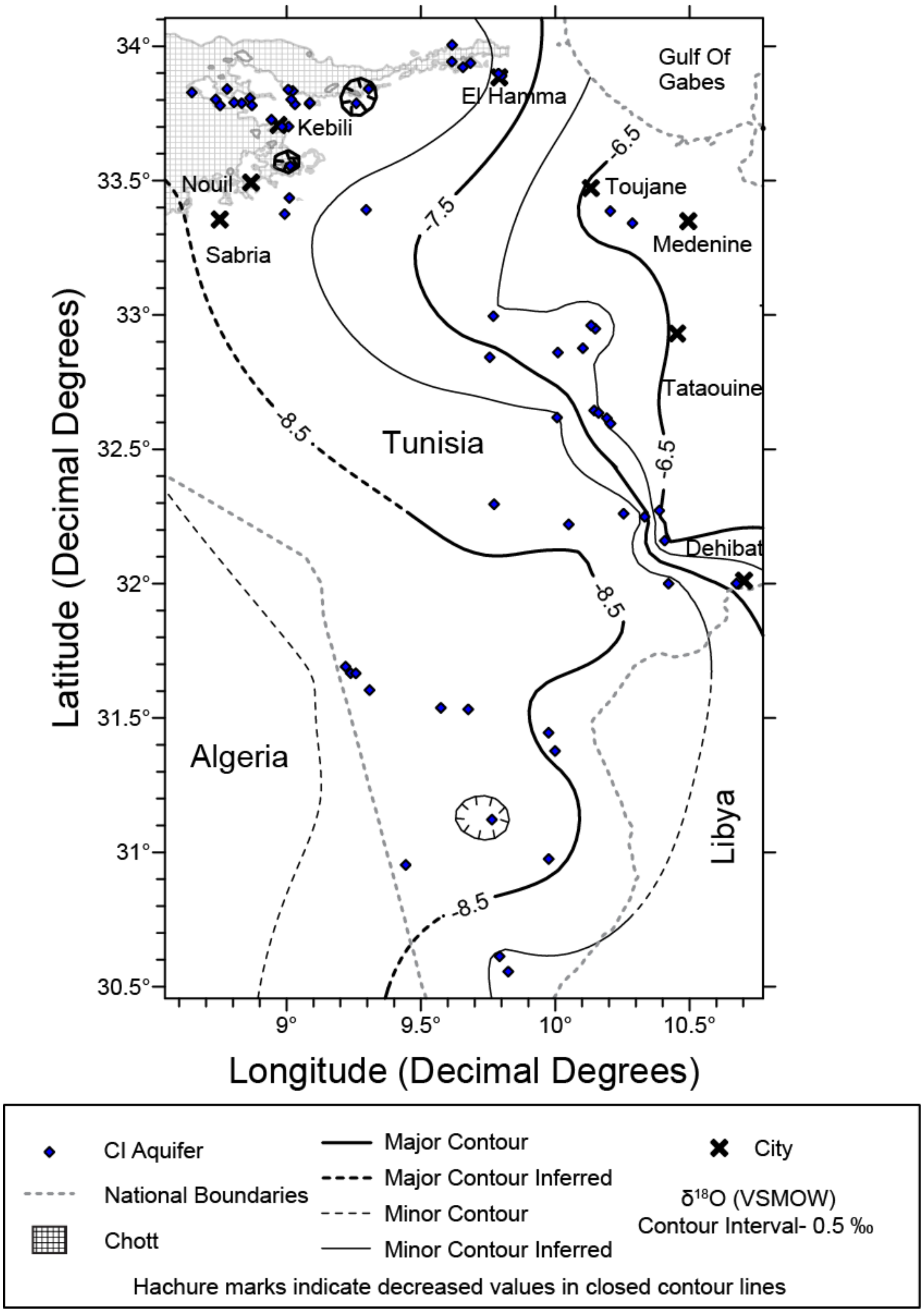


Fig. 24 $\delta^{18}O$ contour map of the Continental Intercalaire aquifer in Tunisia

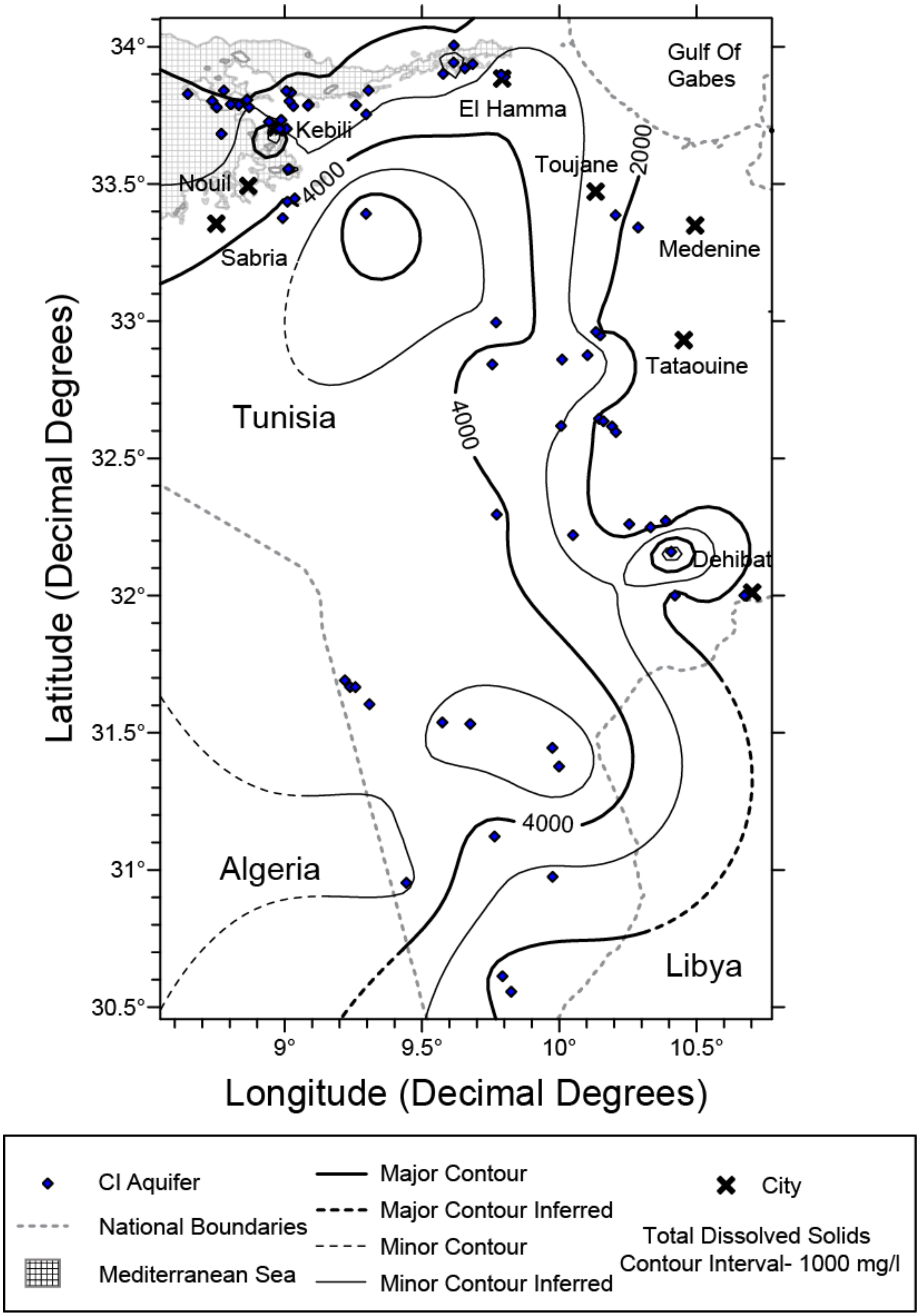


Fig. 25 TDS contour map of the Continental Intercalaire aquifer in Tunisia

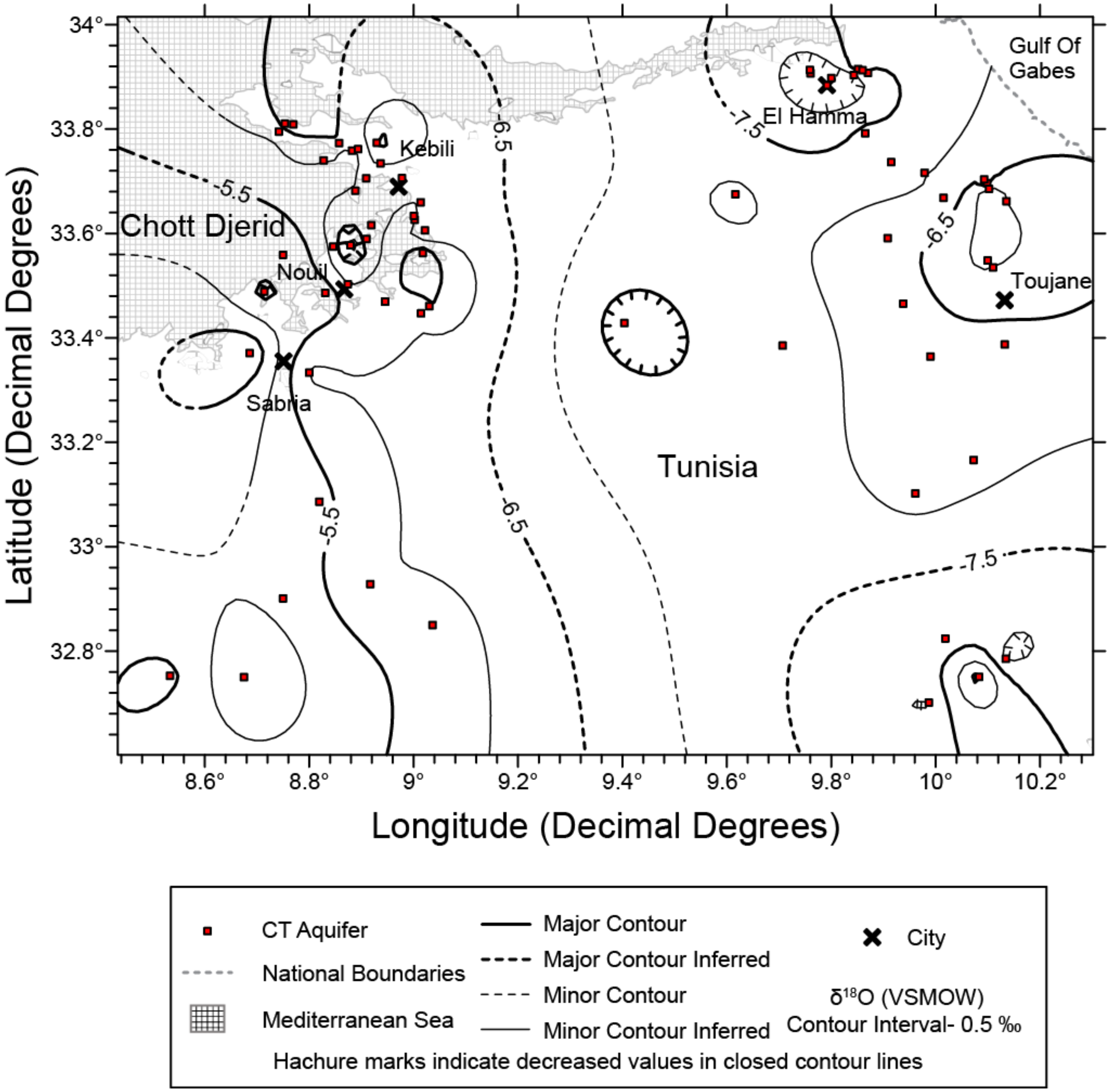


Fig. 26 $\delta^{18}O$ contour map of the Complex Terminal Aquifer in Tunisia

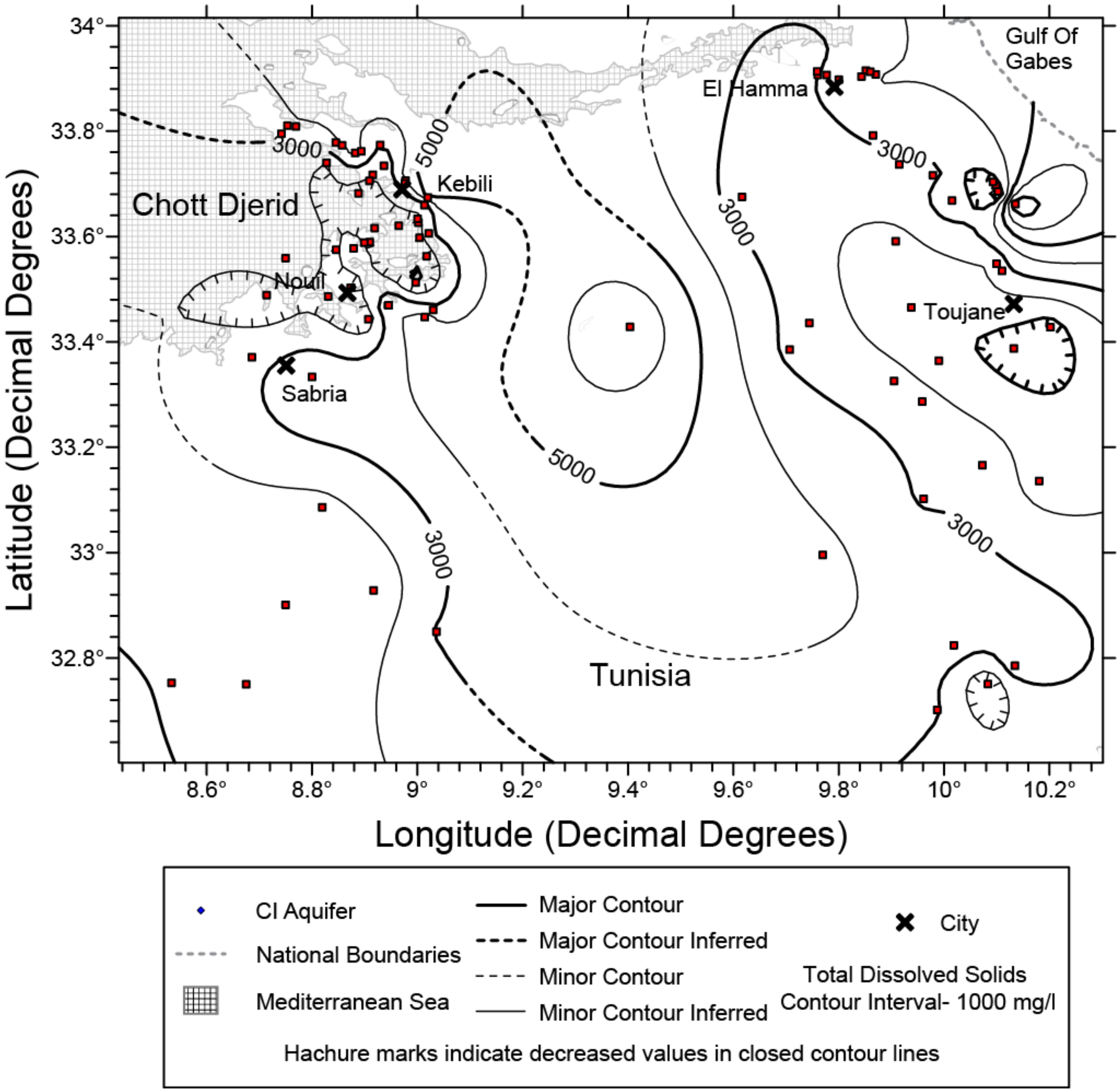


Fig. 27 TDS contour map of the Complex Terminal Aquifer in Tunisia